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SID 62-202

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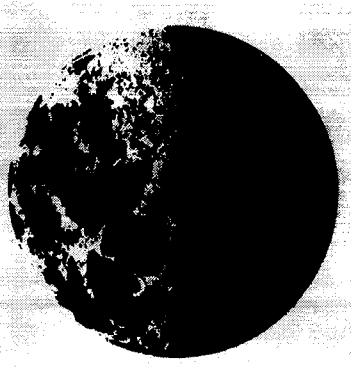
# PRELIMINARY APOLLO MAINTENANCE PLAN (U)

1 May 1962



# Apollo

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# PRELIMINARY APOLLO MAINTENANCE PLAN (U)

1 May 1962

Approved by

J. W. Paup
Vice President and Apollo Program Manager

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# CONTENTS


| Section | | Page |
|---|---|---|
| | OBJECTIVES | 1 |
| | MAINTENANCE CONCEPT | 3 |
| | Maintenance Support Policy | 3 |
| | Quality Control Requirements | 5 |
| | Test Site Maintenance Flow | 8 |
| | Factory Maintenance Flow | 11 |
| | Spares Verification | 14 |
| | Spares Requirements | 14 |
| | MAINTENANCE FACILITIES | 19 |
| | Air Force Plant 16 | 19 |
| | AMR Facilities | 22 |
| | MAINTENANCE DETERMINATIONS | 37 |
| | Systems Test Plan | 37 |
| | Maintenance Support Functional Drawings | 37 |
| | Operational Support Analysis | 37 |
| | Data Administration Program | 38 |
| | Configuration Control | 46 |
| | MAINTENANCE RESPONSIBILITY | 49 |
| | MAINTENANCE ANALYSIS | 51 |
| | Operational Support Analysis | 51 |
| | Reparable Analysis | 53 |


## APPENDIXES


| Appendix | | Page |
|---|---|---|
| A | Maintenance Support Functional Flow Drawings | A-1 |
| B | Glossary | B-1 |

# ILLUSTRATIONS


| Figure | | Page |
|---|---|---|
| 1 | Test Site Maintenance Flow - Scheduled Maintenance | 9 |
| 2 | Test Site Maintenance Flow - Reparable Equipment | 10 |
| 3 | Factory Maintenance Flow - Reparable Equipment | 12 |
| 4 | Factory Maintenance Flow - Scheduled Maintenance | 13 |
| 5 | Spares Verification (Scheduled) | 15 |
| 6 | Spares Requirements and Probable Points of Installation | 17 |
| 7 | Location Plan for Air Force Plant 16 | 20 |
| 8 | Tentative Systems Integration and Checkout Facility | 21 |
| 9 | Merritt Island Industrial Area Site Plan - NASA Facilities | 23 |
| 10 | AMR-MSC Operations and Checkout Building - First Floor Plan | 25 |
| 11 | AMR-MSC Operations and Checkout Building - Second Floor Plan | 27 |
| 12 | AMR-MSC Operations and Checkout Building - Third Floor Plan | 29 |
| 13 | AMR-MSC Operations and Checkout Building - Fourth Floor Plan | 31 |
| 14 | AMR-MSC GSE Storage Building | 33 |
| 15 | AMR-MSC GSE Storage Building Shop Area | 35 |
| 16 | Quality Assurance Organization Chart | 45 |
| 17 | Reparable Component Analysis Flow | 56 |
| A-1 | Maintenance Support Functional Flow (Gross) | A-7 |
| A-2 | Maintenance Support Functional Flow (Task Identification) | A-9 |

# OBJECTIVES

The principal objectives of the Apollo Maintenance Plan are as follows:

1. To establish a maintenance system through use of maintenance/support functional drawings.

2. To provide a means for S&ID and the NASA to establish a pool of pertinent and validated information on the various elements of the spacecraft and ground support equipment at the earliest possible date. This information will be oriented to Apollo logistic and maintenance support.

3. To provide a means to coordinate up-dating and validating of information with the development of the spacecraft and ground support equipment.

4. To provide data which may be analyzed and evaluated at an early date to support the S&ID maintenance and logistic concepts.

5. To provide a means by which identification of resources, tools, training, and other pertinent data may be developed and maintained current with the state of Apollo spacecraft development.

In order to accomplish the objectives of the Maintenance Plan, it has been necessary to develop and satisfy the logistic and maintenance requirements concurrently with the release of the System Test Plan and S&ID engineering drawings.

Personnel requirements, training, tools and equipment, facilities, maintenance levels and policies, support manual data, and supply requirements are determined from the characteristics limitations, configurations, and capabilities that are inherent in the hardware design. Evaluations of these detailed analyses of each item of hardware will establish the total dimensions for all maintenance requirements none of which can be independently developed. These can and must be developed concurrently with the hardware system. Once defined, the detailed information collected in each category may be utilized in numerous combinations to accomplish programming, planning, and the implementation of efficient maintenance actions.

The Preliminary Apollo Maintenance Plan establishes and describes a systematic implementation of a maintenance system conceived to meet the stringent requirements of the Apollo program. In order to provide realistic maintenance planning, each individual task accomplished to prove the Apollo spacecraft development will be analyzed. When data developed from each task has been compiled, analyzed, evaluated, and properly applied to the Apollo operational program, precise information for a flexible and expeditious maintenance plan will be generated. Maintenance and supply orientation will be provided for training requirements, levels of maintenance, spares selection, facilities requirements, support manual data, and provisioning. These data will be available on a timely basis to assure the proper logistic and maintenance support of the Apollo test program.

# MAINTENANCE CONCEPT

## MAINTENANCE SUPPORT POLICY

The Apollo maintenance/support concept encompasses the command module, the service module, and the ground complex described in specification SID 62-65. Its objective is to sustain mission phase reliability and crew safety requirements. Programmed maintenance of prototype spacecraft; flight rated systems; and GSE at designated locations, S&ID, AMR, and other base areas are described in this section.

### Flight Equipment

Performance of spacecraft systems, subsystems, or components determined to be subnormal during checkout will be replaced with test support hardware and/or critical matching spacecraft support parts. The removed items will be delivered to Section 1, Mission Essential Equipment Test Bench Maintenance Area for further interrogation. Equipment found to be functional within specification requirements will be certified and returned to spares. Equipment found to be degraded will be delivered to a failure analysis laboratory at S&ID or AMR for reliability analysis and disposition.

As a normal procedure, no electrical or mechanical maintenance repairs will be made within the spacecraft on any critical types of equipments or components that can be removed from the vehicle nor will repairs be made on degraded flight equipment at the Mission Essential Equipment Test Bench Maintenance Area.

Maintenance servicing or repair of fixed spacecraft elements will be conducted in accordance with quality assurance procedures.

### Ground Complex Equipment

The reliability ground complex plan is included in the specifications outlined in Paragraph 9.2, SID 62-65. This plan comprises three major reliability sections:

Section I, Mission Essential Equipment (MEE)

Section II, Operating Ground Equipment (OGE)

Section III, Support Ground Equipment (SGE)

The type of ground support equipment integrated within each section, including the respective bench maintenance equipment of each section, will be maintained as outlined in the following paragraphs:

Mission Essential Equipment

The ground support equipment, Section I (MEE), that is functional with the spacecraft mission systems will be maintained by proper calibration and adjustments. Equipment found to be beyond limits of adjustments, including malperformance and failures, will be replaced with certified spares. The removed items will be delivered to the MEE test bench maintenance area for further interrogation, as outlined for flight equipment.

As a normal procedure, no electrical or mechanical maintenance repairs will be made within the GSE units at station locations on critical types of equipment or components that can be removed from the console. Normally, no repairs will be made on any GSE delivered to the MEE test bench maintenance area.

Maintenance servicing or repair of fixed elements within a GSE console at station location will be in accordance with quality assurance procedures.

Operating Ground Equipment

Section II functional OGE maintenance will be as described for ground complex equipment. With one exception, items removed will be delivered to the OGE test bench maintenance area for further interrogation.

Mission Essential Equipment Test Bench Maintenance Area

Test bench maintenance equipment of Section I and II bench areas will be maintained by use of certified laboratory test equipment. Marginal equipment will be replaced, and normally, no repairs will be made on this marginal equipment at the bench maintenance area.

Support Ground Equipment

Section III functional SGE shall be maintained at respective SGE locations. Normal replacement, repairs, and overhauls may be made at locations defined in the quality assurance procedures.

Equipment Handling Techniques

In the interest of sustaining mission phase reliability and crew safety requirements, it is essential that all equipment removed from the spacecraft or GSE consoles for either scheduled or off-scheduled maintenance that

requires controlled environmental handling be processed using white room techniques. Equipment will be packaged in plastic bag containers to prevent undue contamination during transit and handling. Precision equipment will be packaged in accordance with shock and vibration specifications outlined in SID 62-65.

## QUALITY CONTROL REQUIREMENTS

Quality control requirements for the maintenance of GSE and spacecraft components for the Apollo program will parallel the quality control requirements imposed on the manufacture of Apollo components. All phases of overhaul, repair, preventive maintenance, and modification will be accomplished in accordance with applicable S&ID and Government specifications and be so performed that components will be restored to their original serviceability.

Repair or modification of Government furnished equipment (GFE) will not be initiated without the prior approval of the responsible Government agency.

### Quality Control, Bench Maintenance

Quality Control holds surveillance over processes to assure their conformance to engineering drawings and specification requirements. Quality Control personnel will also have surveillance over cleanliness and orderliness of all areas and over periodic particle counts in dust-controlled areas. Automatic surveillance will be maintained over those areas which are temperature and humidity controlled. Recording equipment will be employed in addition to the environment-control equipment.

Parts and components will be properly identified through all detail processing. If the process obliterates the previous identification, Quality Control will ensure a means to maintain identification throughout the process, and to record any necessary re-identification.

### Acceptance Inspection, Manufacturing Reprocessing Bench Maintenance

Quality Control personnel will monitor and verify all phases of overhaul, repair, and modification processes to ensure product quality. Surveillance will be maintained over disassembly, cleaning, repair or replacement, modification, recalibration and checkout in compliance with applicable specifications and detailed operating procedures. When it is determined that authorized tolerances of a part may be exceeded as a result of normal wear before the next scheduled maintenance period, the questionable part will be replaced or repaired as necessary.

Equipment shall be disassembled only to the extent necessary to clean and inspect for unserviceable parts, and to accomplish the necessary repairs. Identification of items will be preserved and documented. Quality Control will initiate a positive corrective action cycle to correct discrepancies and prevent recurrence of similar discrepancies.

Inspection of Boilerplate Overhauled or Repaired Items

All repaired, overhauled, or modified items and assemblies for boilerplate models will be inspected in accordance with design criteria and applicable procedures. No inspection or quality processes that will negate or invalidate the end test objective will be omitted from the acceptance testing of the boilerplate parts or assemblies.

Procurement Inspection

Procurement Quality Control will perform the necessary coordination to ensure that all articles returned from supplier after repair, overhaul, or modification meet the high-quality standards required for the Apollo Program.

Repaired, overhauled, or modified equipment will be inspected at the source when it is not feasible, practical, or economical to perform a receiving inspection at S&ID. Quality Control will station a representative at the major subcontractors' facilities to perform this inspection. Final inspection of complex reworked equipment will be witnessed at the subcontractor's facilities. Final inspection of less complex equipment will be verified in receiving inspection. In all cases, final inspection will be accomplished in accordance with S&ID test plans.

Receiving Inspection

Quality Control's functions in this area will include 100-percent inspection of critical characteristics and necessary tests on all incoming spares or reworked items for conformance to company and contractual requirements. Results of this inspection will be recorded and analyzed for further action and will be used for reliability assessment and corrective action purposes. Any rejected material or component will be appropriately marked and segregated for processing through material review or material rejection procedures for return to the supplier.

Process Control

Quality Control maintenance surveillance over the cleaning process will include checking solutions for the concentrations required in customer and S&ID quality control specifications. Solution changes and additions and

solution temperatures will be under continual surveillance. Cleaned components for liquid oxygen, liquid hydrogen, and pneumatic systems will be inspected for conformance with applicable specifications. Quality control checks for Ph factor will be made at prescribed intervals, and the results will indicate the corrective action necessary to maintain proper consistency.

Preservation, Packaging, Packing, and Shipping

Quality Control will assure preservation, packaging, packing, marking, identification, and handling of all overhauled, repaired, or modified items throughout all phases of receiving, maintenance, and shipment.

## Inspection and Test Records

Requirements

In accordance with quality program provisions for space system contractors, NPC 200-2 dated 1 March 1962, Quality Control will establish, accumulate, and maintain records of all inspections, calibrations, process control, material dispositions, corrective action, etc. These records will reflect compliance with specification requirements and engineering changes, and certification requirements and will provide for meaningful data acquisition for the purpose of evaluation, analysis, and determination of reliability and problem areas. A complete history of each item repaired, overhauled, or modified will be available to NASA at time of acceptance.

Nonconformance and Corrective Action

S&ID's material review system assures effective review, disposition, and control of nonconforming articles. A single, nonconforming-material reporting document is used to report and record description, circumstances, probable cause, on-the-spot corrective action, tests, analysis, and disposition of material. The document is a multisheet form suitable for duplication and transmittal of data for central machine processing. This documentation provides backup information for Material Review Board decision, corrective action measures to prevent recurrence of nonconforming material, and supporting information for an effective product reliability program. A similar and supplementary form is used for direct corrective action assignment, recording actions taken, and verification of effectivity.

Reporting, disposition of nonconforming material, corrective action requirements, and closed loop follow-up is the responsibility of the Material Review section of Quality Engineering. Corrective action requiring quality

improvement is assigned to Quality Engineering, and manufacturing improvement is assigned to the appropriate manufacturing group. Time limits are imposed with provisions for feedback control.

To prevent repeated manufacture of nonconforming materials, the item is not accepted until satisfactory action is taken. Positive follow-up and documented confirmation of remedial action to prevent recurrence is required before the release of material. A copy of all actions taken involving nonconforming material is sent to the Quality Assurance data center to be encoded and transmitted to Data Processing, where periodic and special reports are published for use in analysis and reporting activities. The working file on all nonconforming material actions is maintained by the material review office of Quality Engineering for ready access to all concerned in the elimination of nonconforming material. Complete case histories are forwarded to the Quality Assurance data center.

### Test and Measuring Equipment

All test and measuring equipment used in acceptance testing of an operation or an item will be calibrated and maintained periodically. Current, valid evidence of such calibration and maintenance will be documented. All calibrations must be traceable to one or more S&ID reference standards, certified by the National Bureau of Standards (NBS), or other approved agencies.

Specifications will be established specifying the calibration, maintenance, and related requirements for each type of test or measuring equipment. Calibration and maintenance intervals shall be established to assure continued conformance to applicable procedures and equipment requirements.

## TEST SITE MAINTENANCE FLOW

### Reparable Equipment

Quality Control, in conjunction with other responsible groups, will provide an expeditious means for processing reparable equipment throughout all phases of repair or overhaul. Quality Engineering Material Review, in conjunction with Reliability Engineering, will make disposition of all S&ID and supplier equipment that require overhaul and repair and are under S&ID responsibility. Quality Control will ensure that the removal of the equipment is properly documented in the work book prior to submitting the equipment to Material Review for disposition. Equipment requiring overhaul or repair beyond the capabilities of the test site maintenance section will be returned to S&ID (Figures 1 and 2). A part replacement request (PRR) and a nonconforming material report (NMR) will be initiated by Quality Engineering

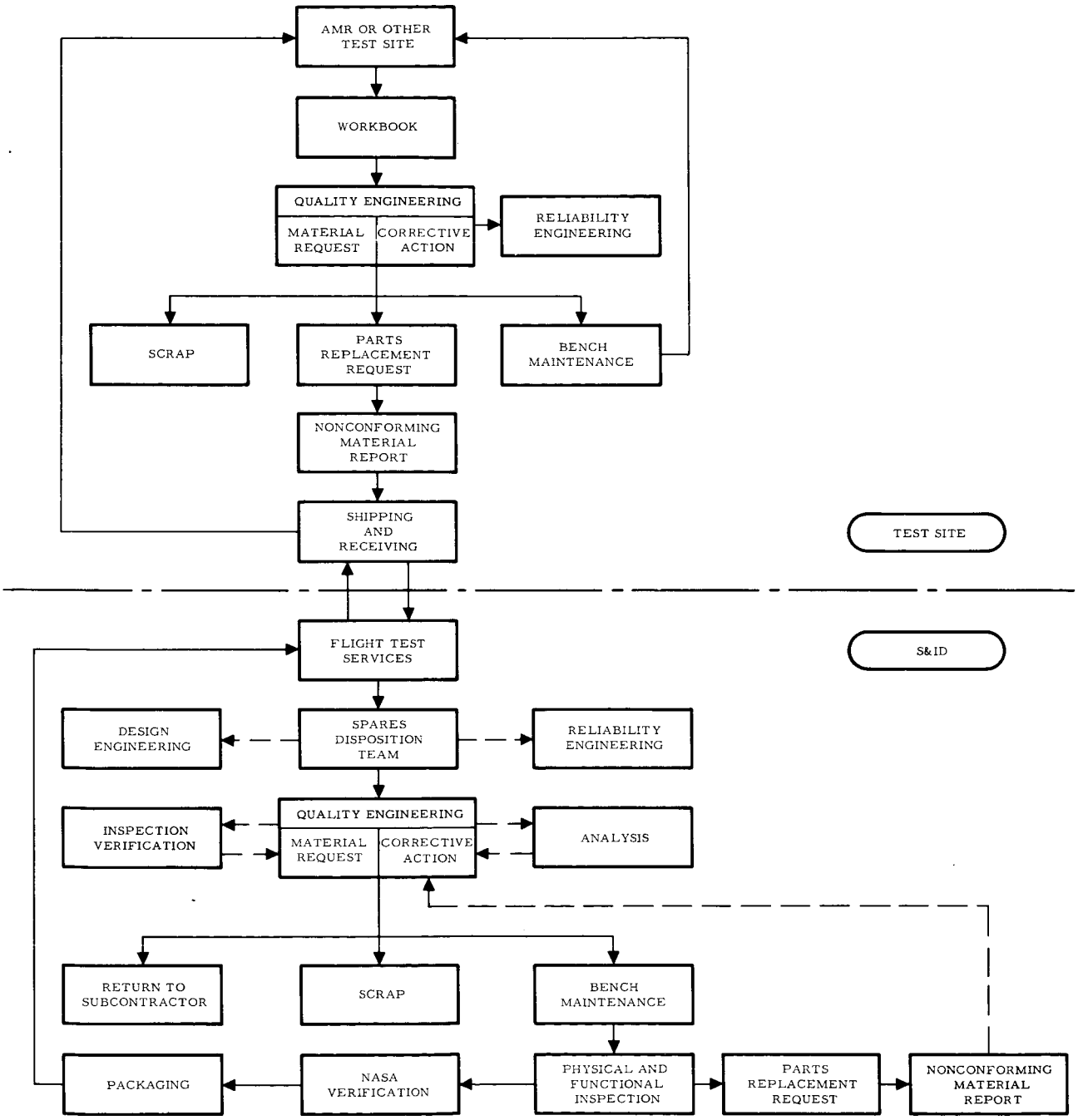


Figure 1. Test Site Maintenance Flow - Scheduled Maintenance

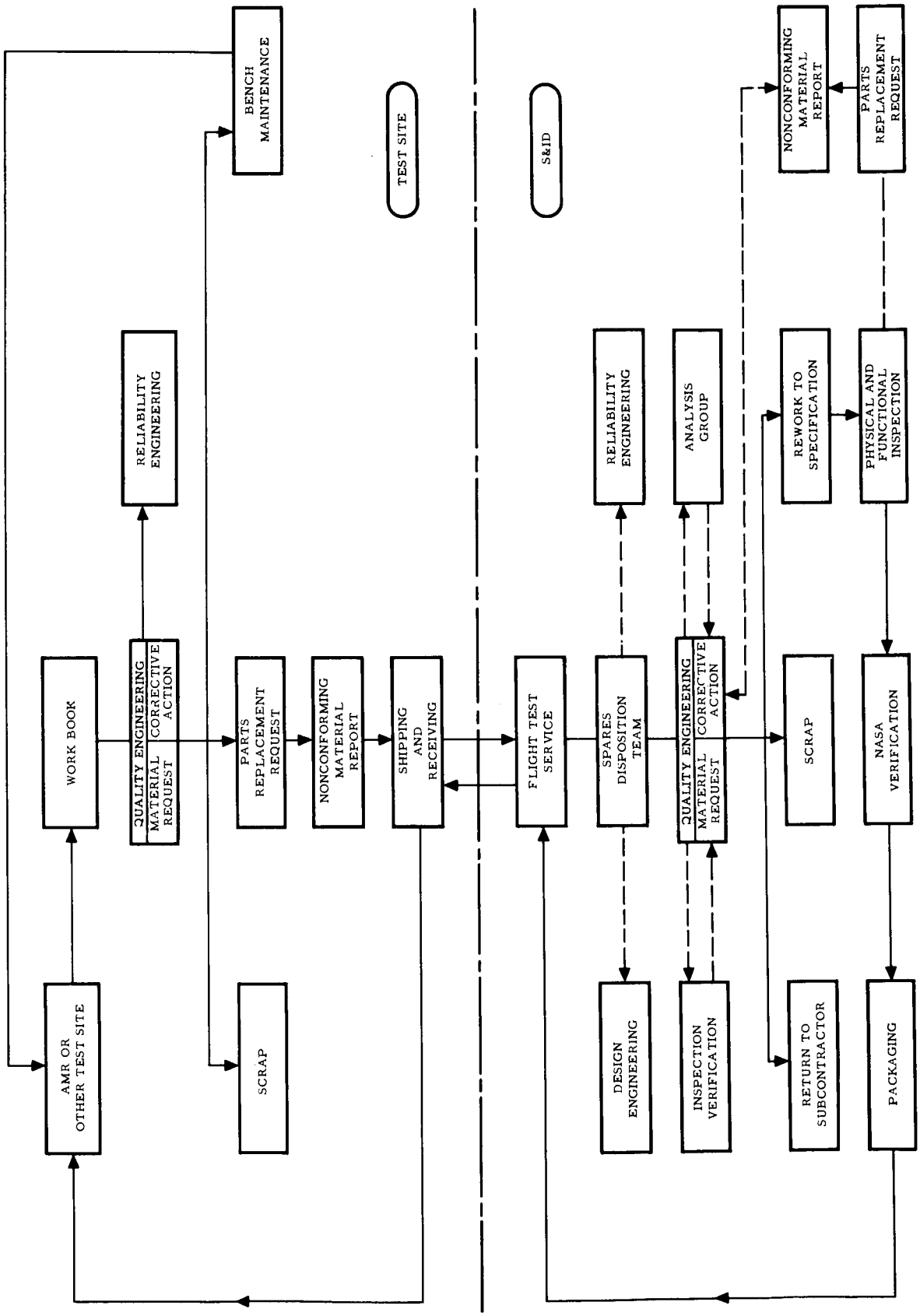


Figure 2. Test Site Maintenance Flow - Reparable Equipment

Material Review prior to shipment of equipment to S&ID. Upon receipt of the equipment at S&ID, Flight Test Services will complete the necessary in-house documents and submit the equipment and documents to the spares disposition team. This team, made up of representatives from Logistics, Quality Assurance, Design Engineering, and Project Integration Manufacturing will analyze and evaluate the requirements as to the need for repair or overhaul of the equipment, taking into consideration any impending design changes. The spares disposition team will also establish priorities necessary to ensure support of the program. The Quality Engineering Material Review section, working in conjunction with the spares disposition team, will make a disposition and determine if it is economically feasible to rework the item. Items requiring a detailed analysis will be sent to a cognizant group to determine the cause of the malfunction. When necessary, Material Review will submit the equipment to inspection for verification of the information stated on the PRR and NMR; Material Review will assign the NMR to the responsible group for corrective action. Quality Control will monitor the overhaul and repair to ensure restoration of the equipment to its original standard of quality and reliability. Supplier-furnished equipment requiring overhaul or repair beyond the capabilities of S&ID Bench Maintenance will be returned to the supplier.

### Scheduled Maintenance

Maintenance of the majority of the equipment in this category consists of calibration maintenance, and will be performed by the test site maintenance section. Certain components with a specified maximum operating life will follow the same procedure as previously outlined.

## FACTORY MAINTENANCE FLOW

### Reparable Equipment

All S&ID and supplier equipment which require repair or overhaul and are under S&ID responsibility will be expedited to ensure prompt rework. Equipment will follow the same in-house maintenance flow as equipment returned from the test sites for rework or overhaul. (See Figure 3.)

### Scheduled Maintenance

All S&ID and supplier equipment that require scheduled maintenance and are under S&ID responsibility will be expedited to ensure prompt maintenance. Equipment will follow the same in-house maintenance flow as equipment returned from the test sites for scheduled maintenance. (See Figure 4.)

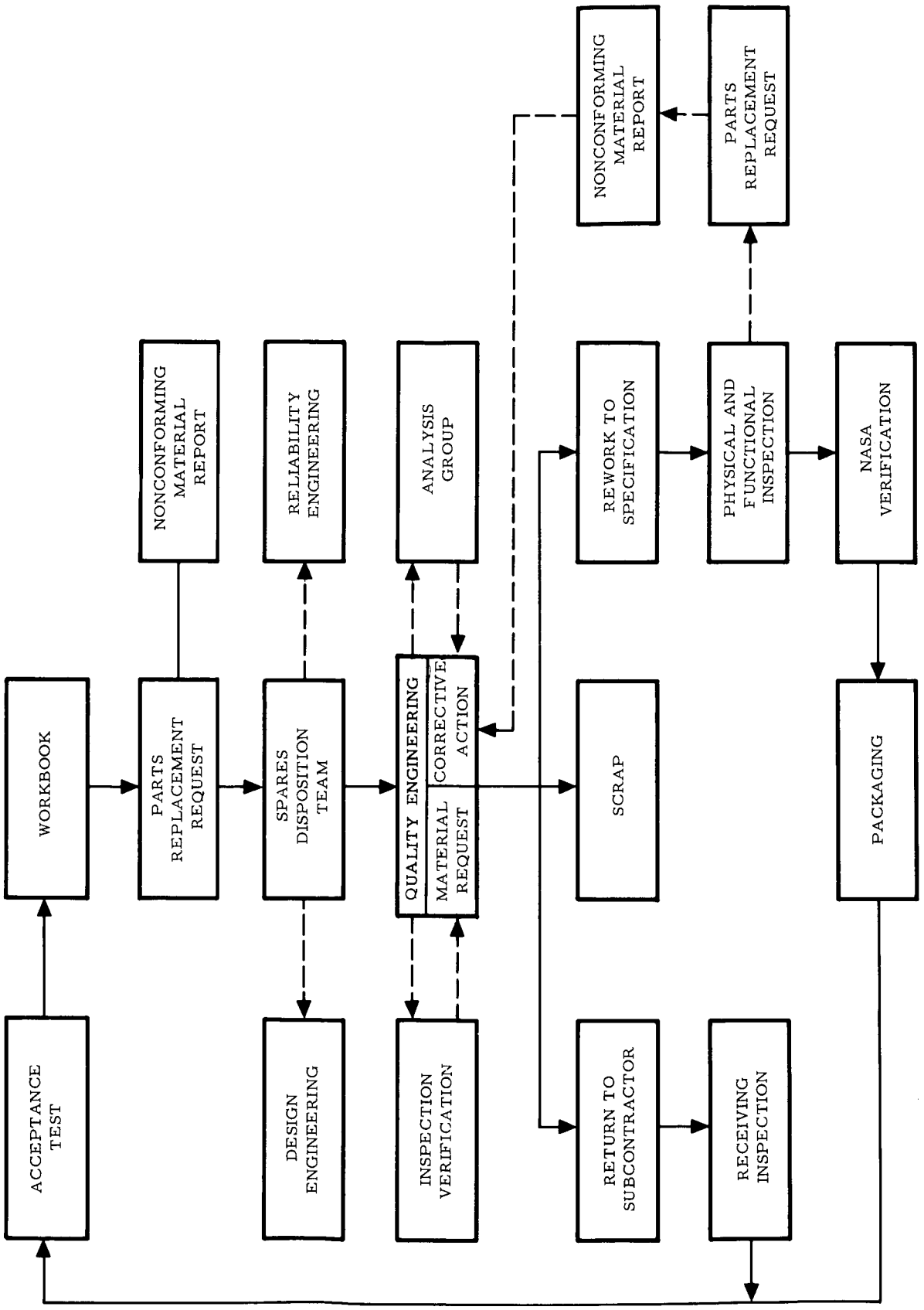


Figure 3. Factory Maintenance Flow - Reparable Equipment

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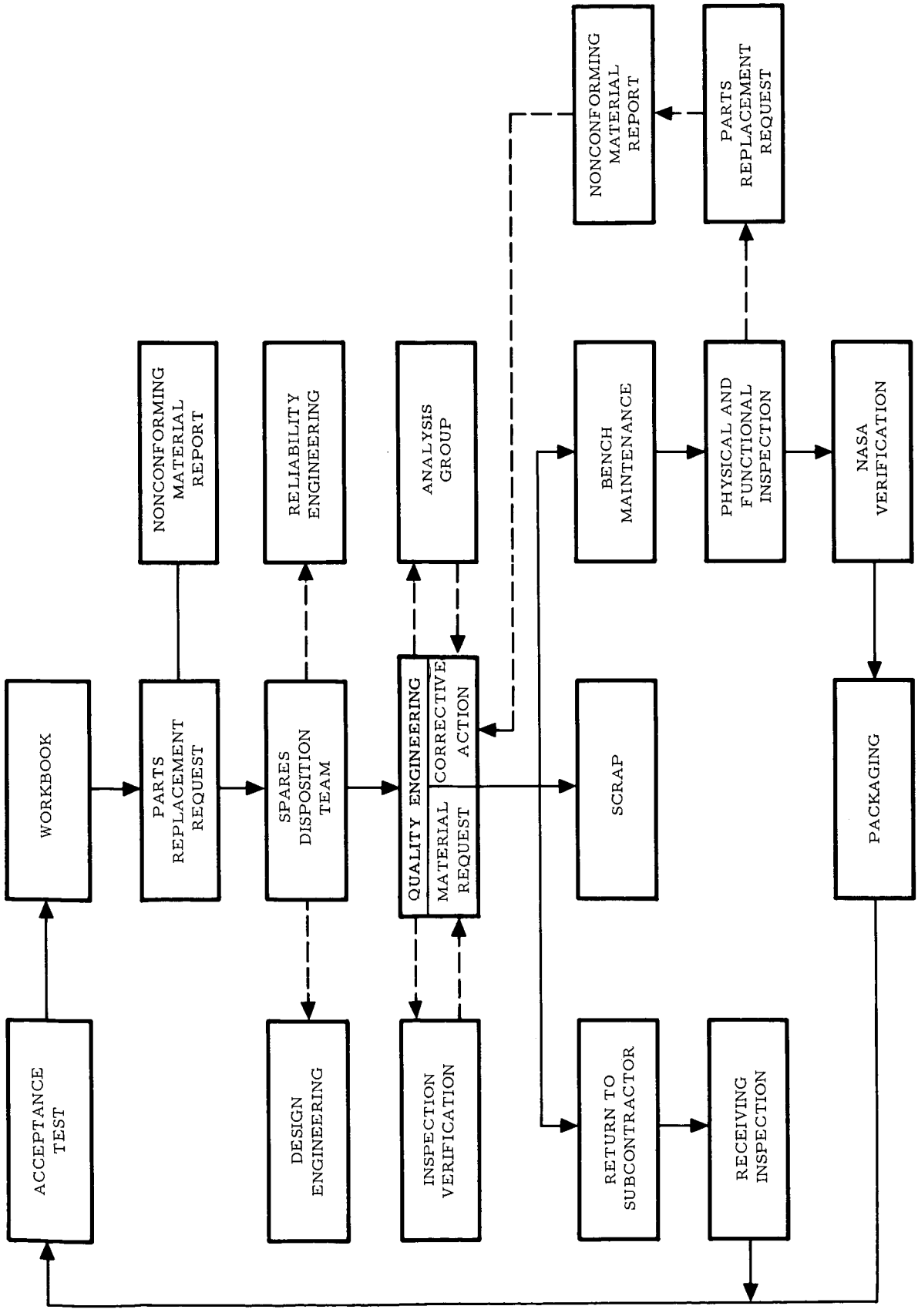


Figure 4. Factory Maintenance Flow - Scheduled Maintenance



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## SPARES VERIFICATION

Spares requiring verification will be processed through the test-site bench maintenance area or the contractor's facility as shown in Figure 5. As the final design of systems, assemblies, subassemblies and components is determined, storage and shelf-life criteria will be developed; and, through this information, a systematic approach to spares verification will be established. Special storage and marking criteria will be developed, and procedures specifying by part number and shelf life will be formulated for those items requiring scheduled verification testing or inspection. Upon termination of the allowable time, the assembly, subassembly, or component will be removed from the warehouse and tagged with a flight test parts replacement request (FTPRR) specifying the reason for removal. The part will be routed to the test-site bench maintenance area or contractor's or subcontractor's facility for verification testing, replacement of time significant items (i.e., "0" rings, seals, etc.), inspection, and repackaging. Units will be date stamped and returned to the warehouse for future use. Withdrawal of time-significant items will be controlled, and issuance will be based on the oldest date appearing on the identification tag.

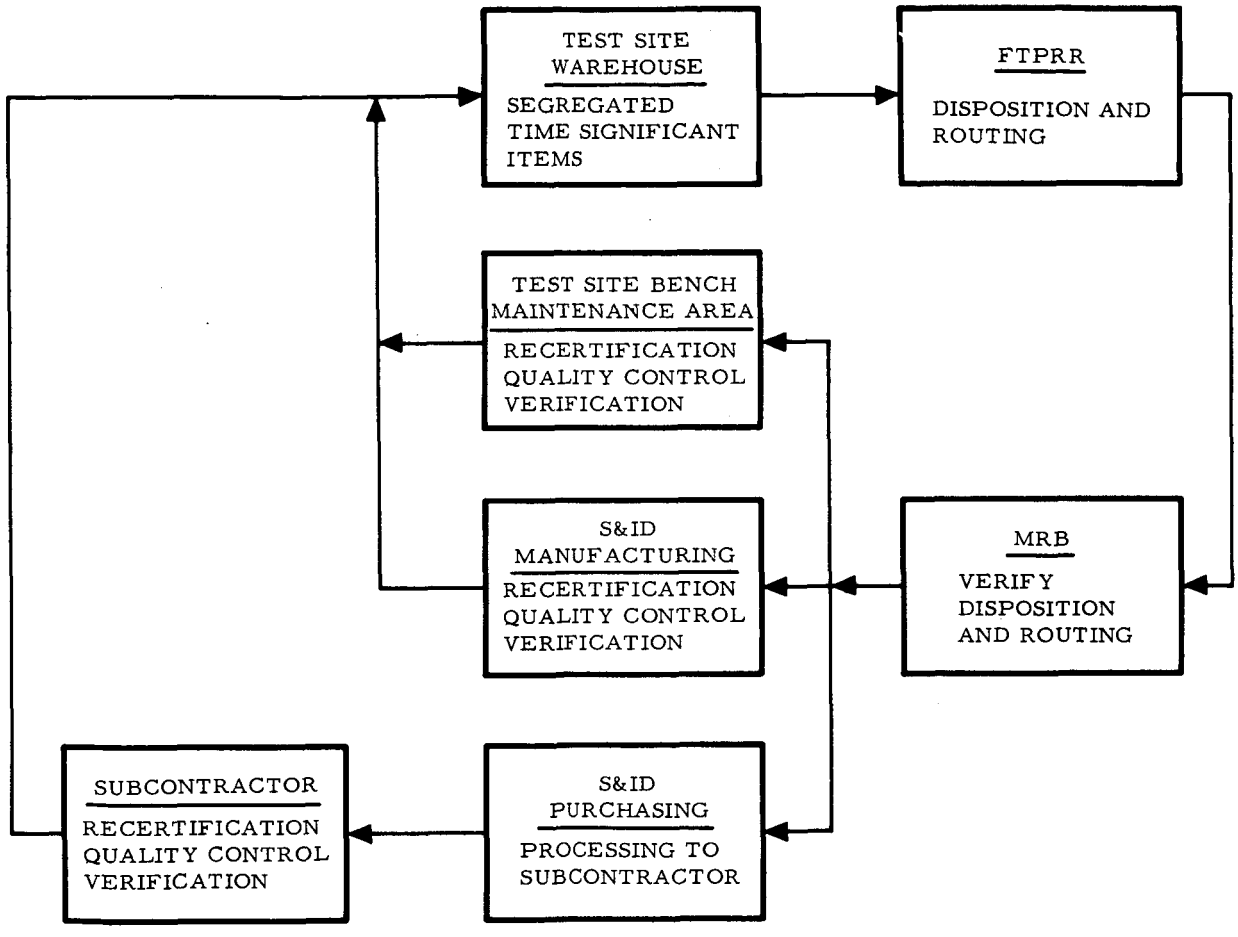
## SPARES REQUIREMENTS

Figure 6 illustrates the probable flow path of the reparable Apollo spacecraft and an anticipated list of spares considered necessary to support the Reaction Control and Service Propulsion System Propellant Systems. The tests listed below the spares components are general tests that will be required as preinstallation acceptance tests. These tests will be conducted at the time of installation and are in addition to the receiving inspection tests.

It is anticipated that the spares will be installed only during engineering acceptance and integrated systems tests at S&ID and in the hangar only at AMR. Subsequent to the installation of a spare component, the entire system will be tested as shown in the applicable block of the spacecraft flow chart of Figure.

The flow chart is an example and submitted only for illustrative and explanatory purposes.

SPARES VERIFICATION (SCHEDULED)




FTPRR FLIGHT TEST PARTS REPLACEMENT REQUEST (FORM 17-A2)

MRB MATERIALS REVIEW BOARD

Figure 5. Spares Verification (Scheduled)

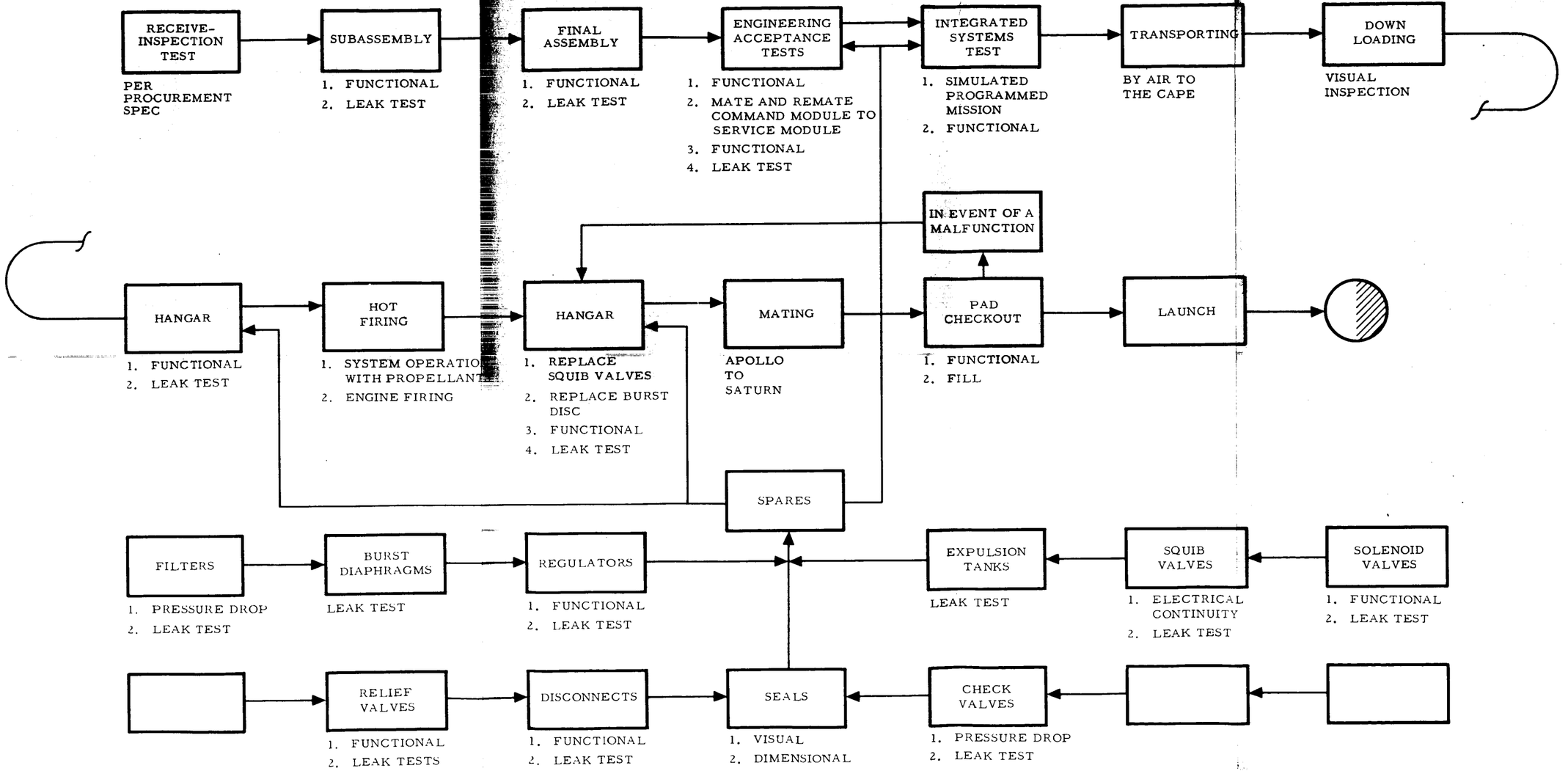



Figure 6. Spares Requirements and Probable Points of Installation

# MAINTENANCE FACILITIES

## AIR FORCE PLANT 16

### General Layout

S&ID will centralize the Apollo Program management, research engineering, and manufacturing activities at its main facilities. Air Force Plant 16, Downey, California (Figure 7).

Existing office areas at the Downey plant are being made available for the Apollo Program management, engineering, and design functions. Adjacent office space will be provided for the NASA representative and staff as well as representatives of major S&ID subcontractors. Building will be modified as necessary, for occupancy by Engineering and support personnel. This modification will include upgrading laboratory and light manufacturing shop areas as shown in Figure 8.

Major fabrication and assembly operations for Apollo components will be conducted at the Downey complex. New facilities will be constructed for system installation, integrated systems checkout, bonding and testing of spacecraft structural components, radiographic inspection of components, and storage of full-scale plaster models. In existing high-bay areas where subassembly operations and training equipment fabrication will take place, overhead handling equipment will be improved.

Development and testing of various systems, components, equipment, and materials in support of the Apollo program will be accomplished at the Downey plant. In addition to the existing laboratory facilities, which will be utilized to the maximum extent, facilities are to be constructed for systems development, integration, and flight acceptance and for water and land impact testing. An area in Building 6 will be modified, as necessary, to house a data reduction and evaluation facility.

### Building

#### Bench Maintenance Area

Systems that fail during separate or integrated systems checkout will be removed to the bench maintenance area for further testing and repair. Those items that are integrated into an assembly and require special handling will be removed and maintained at a high degree of cleanliness while awaiting movement to the bench maintenance area.

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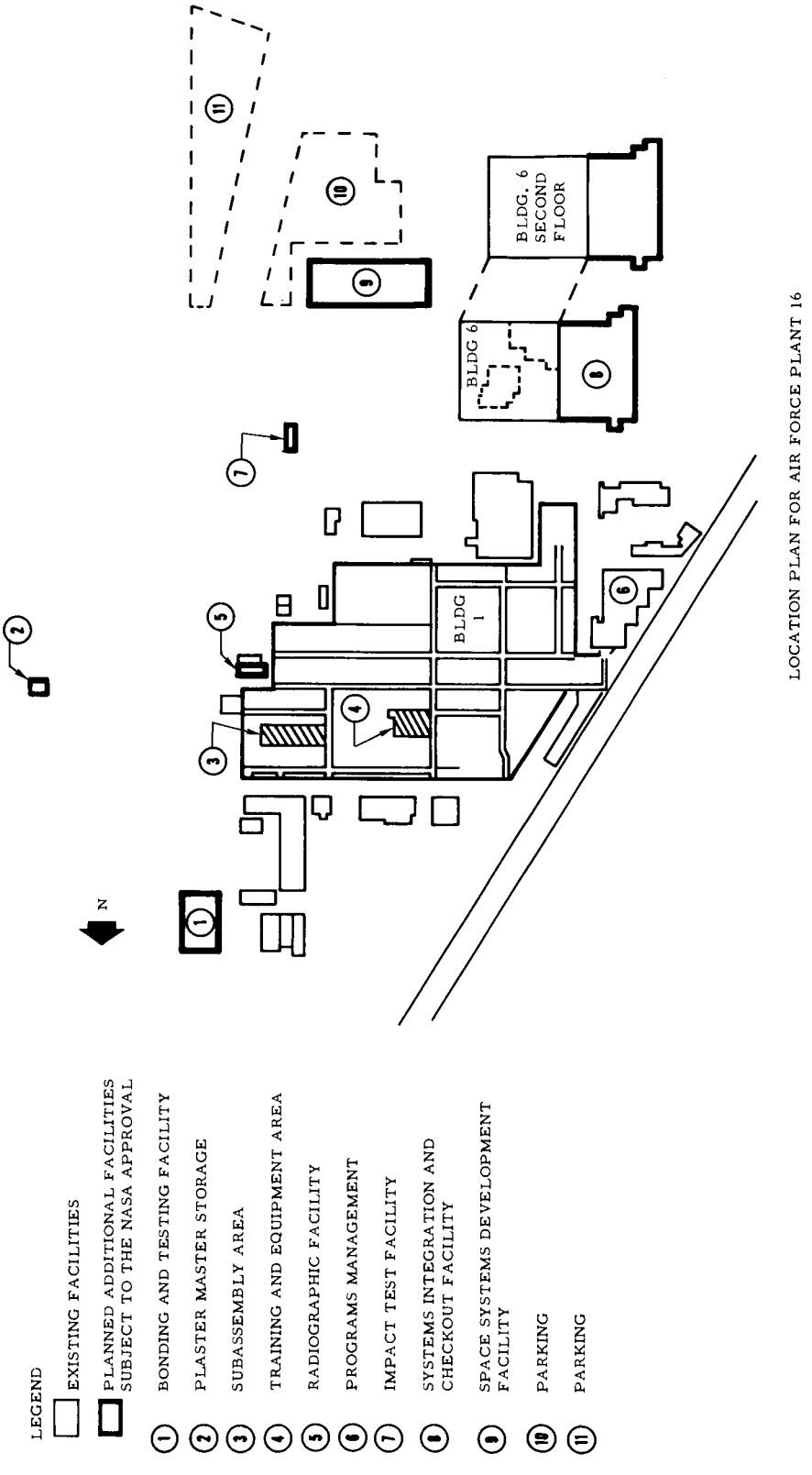


Figure 7. Location Plan for Air Force Plant 16



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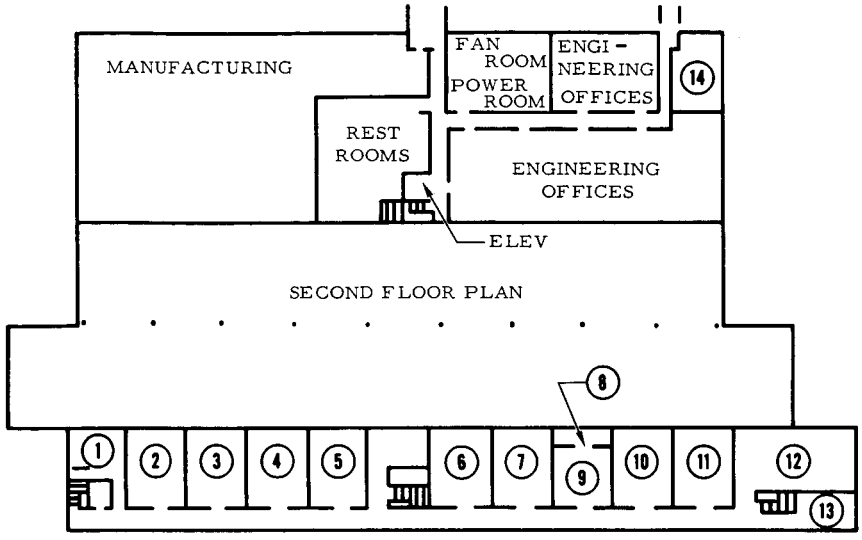
SECOND FLOOR

1. FAN ROOM
2. CHART BRIEFING ROOM
3. CONTROL ROOM
4. CONTROL ROOM
5. CONTROL ROOM
6. CONTROL ROOM
7. CONTROL ROOM
8. OBSERVATORY
9. DATA RECORD
10. CONTROL ROOM
11. CONTROL ROOM
12. GSE CONTROL ROOM
13. FAN ROOM




FIRST FLOOR

1. POWER ROOM
2. STORAGE
3. AIRLOCK
4. AIR-CONDITIONING EQUIPMENT
5. ELECTRICAL SUBSTATION
6. INACTIVE EQUIPMENT STORAGE
7. SHOP
8. TOOLING & SUPPLY
9. COMPARTMENT & STORAGE
10. GSE M&E MAINTENANCE
11. AIRLOCK
12. PARTS CLEANING ROOM
13. AIRLOCK & CLEANER
14. GSE SIMULATOR TEST
15. MFG MALFUNCT & REVIEW

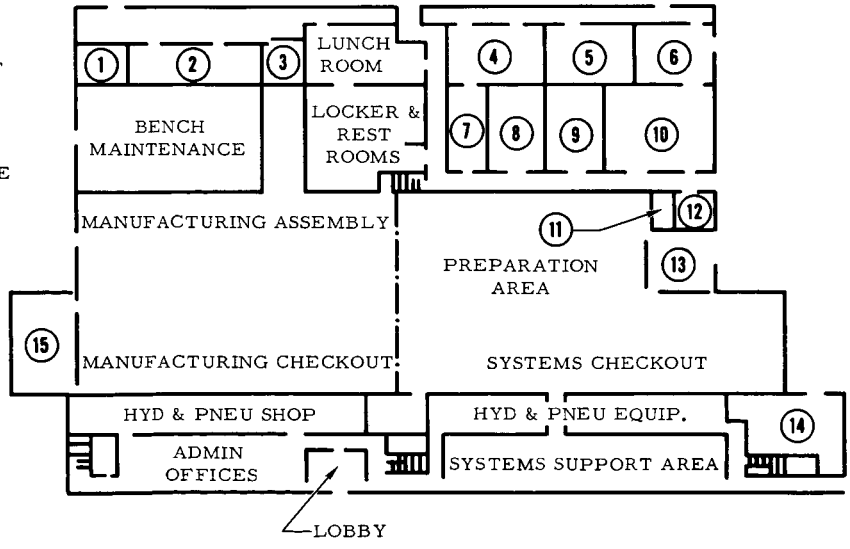



Figure 8. Tentative Systems Integration and Checkout Facility

The bench maintenance area will be maintained at the high state of environmental cleanliness necessary to support evaluation and test for systems having critical environmental requirements. A class B environmentally controlled and electrically shielded modular room will be provided within the bench maintenance area with all necessary equipment. Special power and environmentally controlled air cooling will be provided in the bench maintenance area for systems testing, and facilities will be provided for specialized testing and repair that require the services of systems subcontractors.

Systems Integration and Test Facility

After manufacturing has accomplished a partial integrated systems test, the spacecraft will be moved to the acceptance and house spacecraft testing area. The configuration will be updated, test instrumentation will be installed, functional checks will be performed on individual systems, and a complete integrated systems functional test will be accomplished in the high bay portion of the testing area. Control rooms to house all of the necessary checkout and servicing equipment will be located adjacent to this area.

Fault-isolation functional tests will be performed on modules or subsystems that may malfunction or be suspect during the integrated systems functional tests. Faulty or questionable assemblies will be returned to the manufacturing bench maintenance area for further testing and repair.

AMR FACILITIES

The area arrangement of the AMR maintenance facilities are shown in Figures 9 to 15.

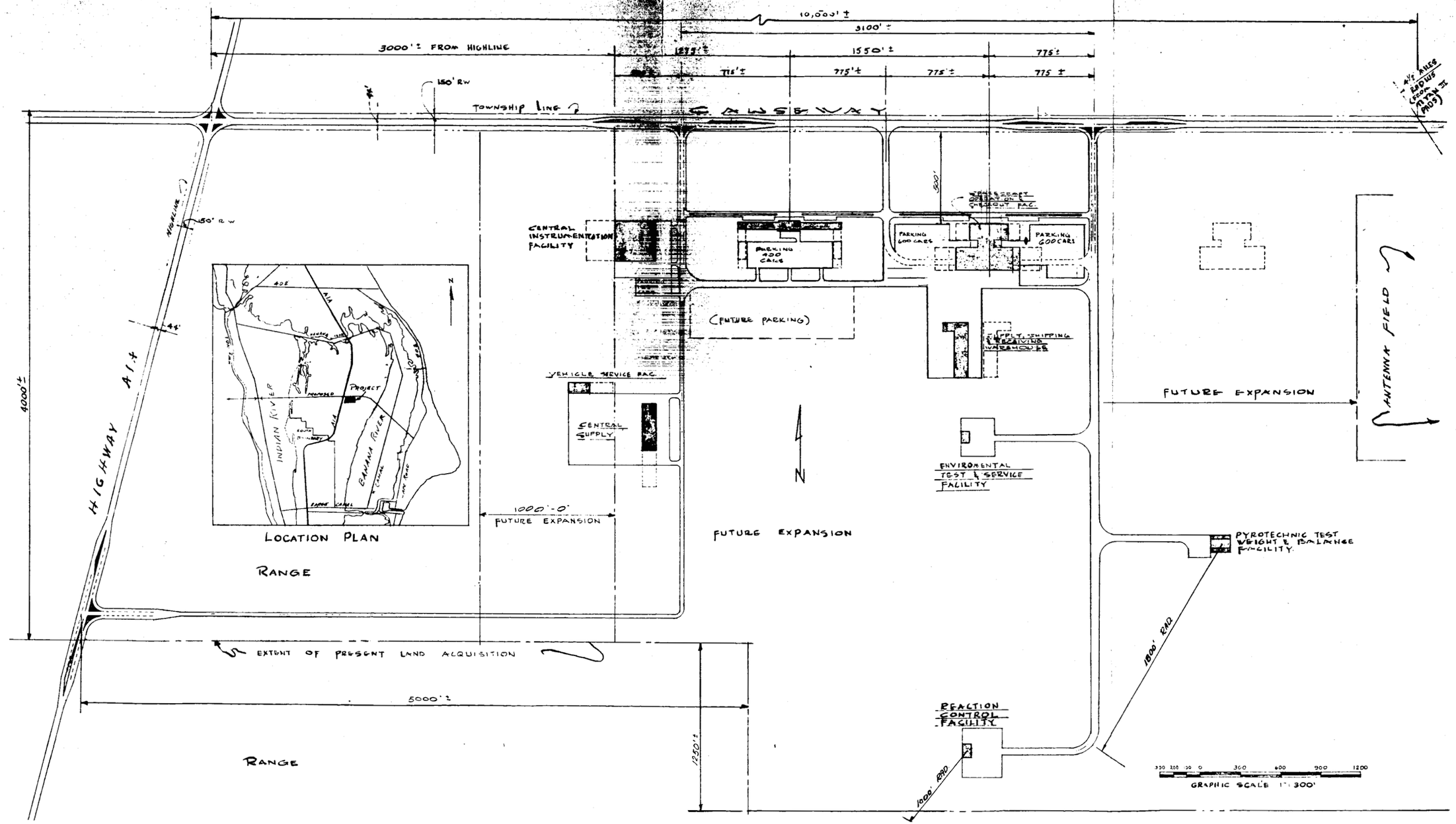



Figure 9. Merritt Island Industrial Area Site Plan - NASA Facilities

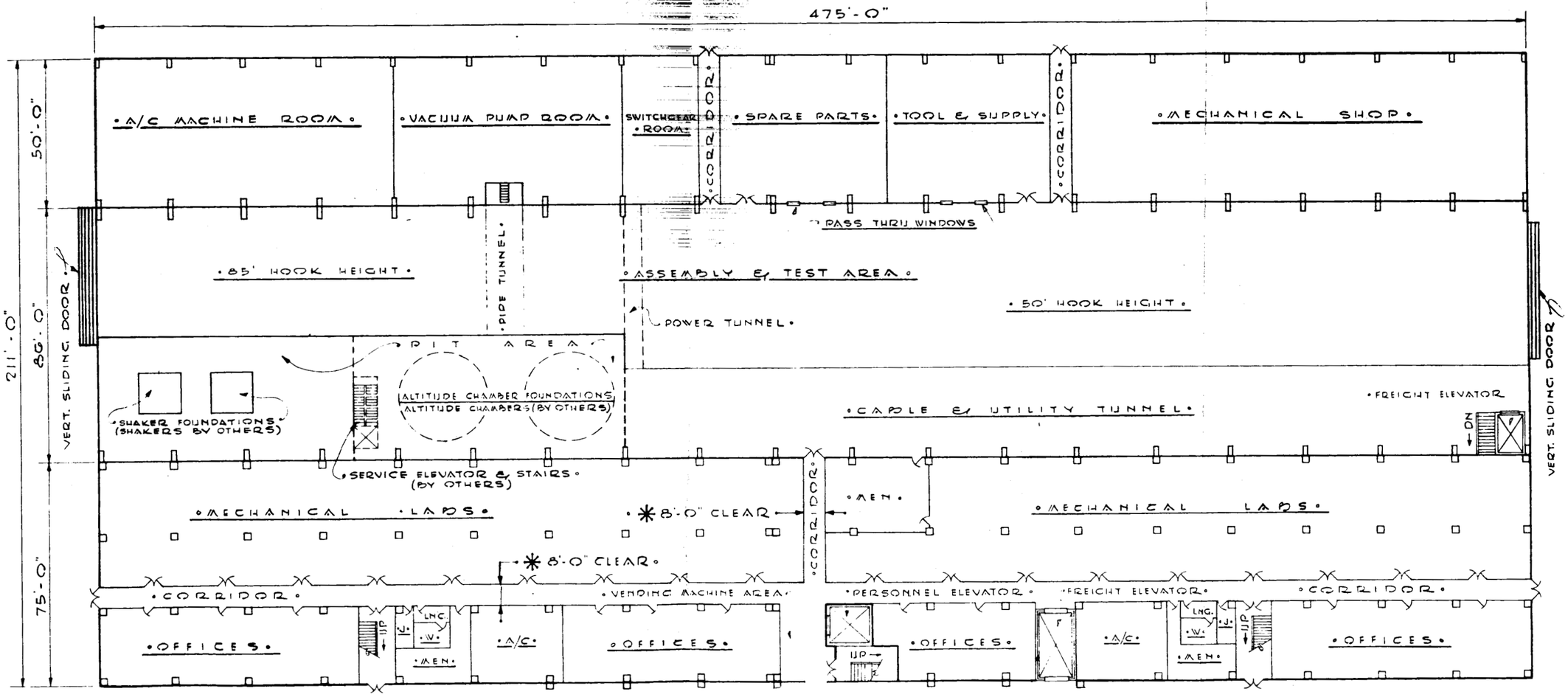



Figure 10. AMR-MSC Operations and Checkout Building - First Floor Plan

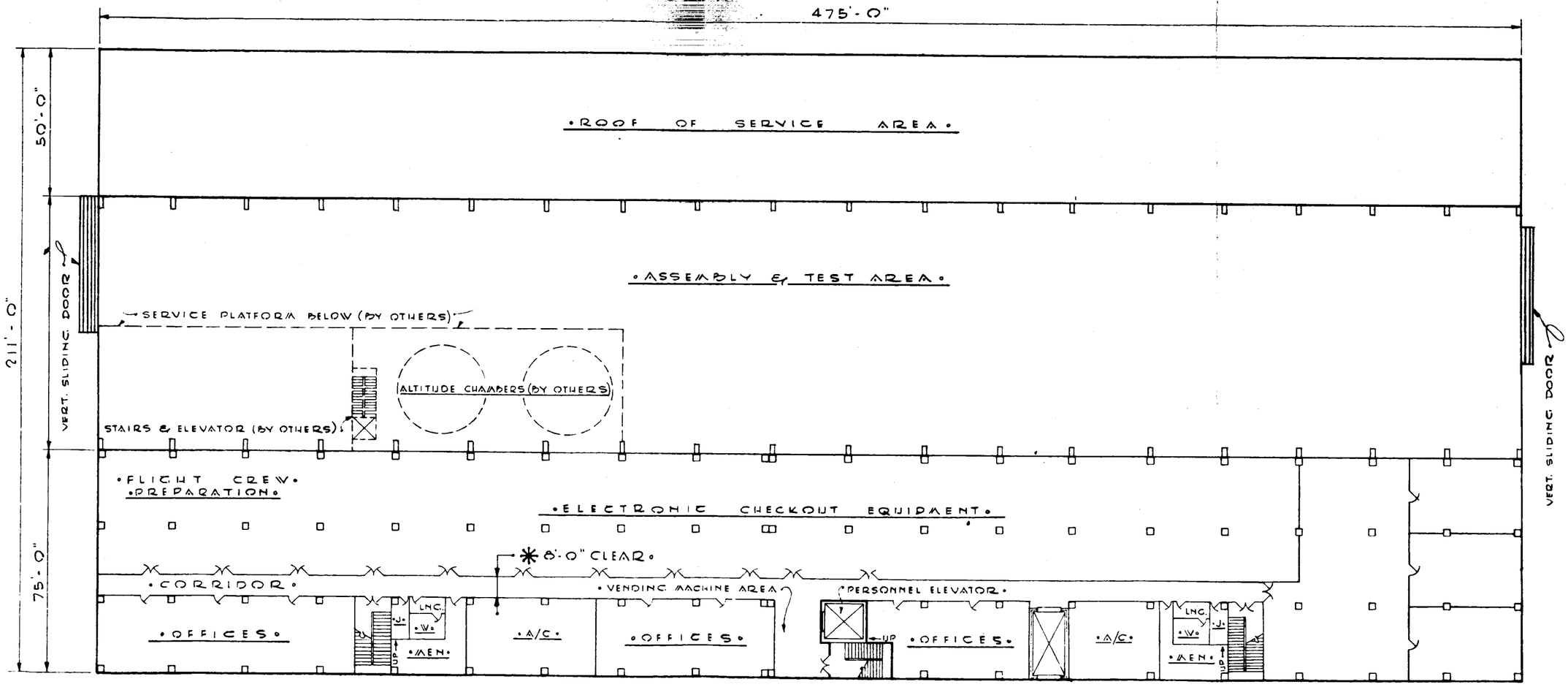



Figure 11. AMR-MSC Operations and Checkout Building - Second Floor Plan

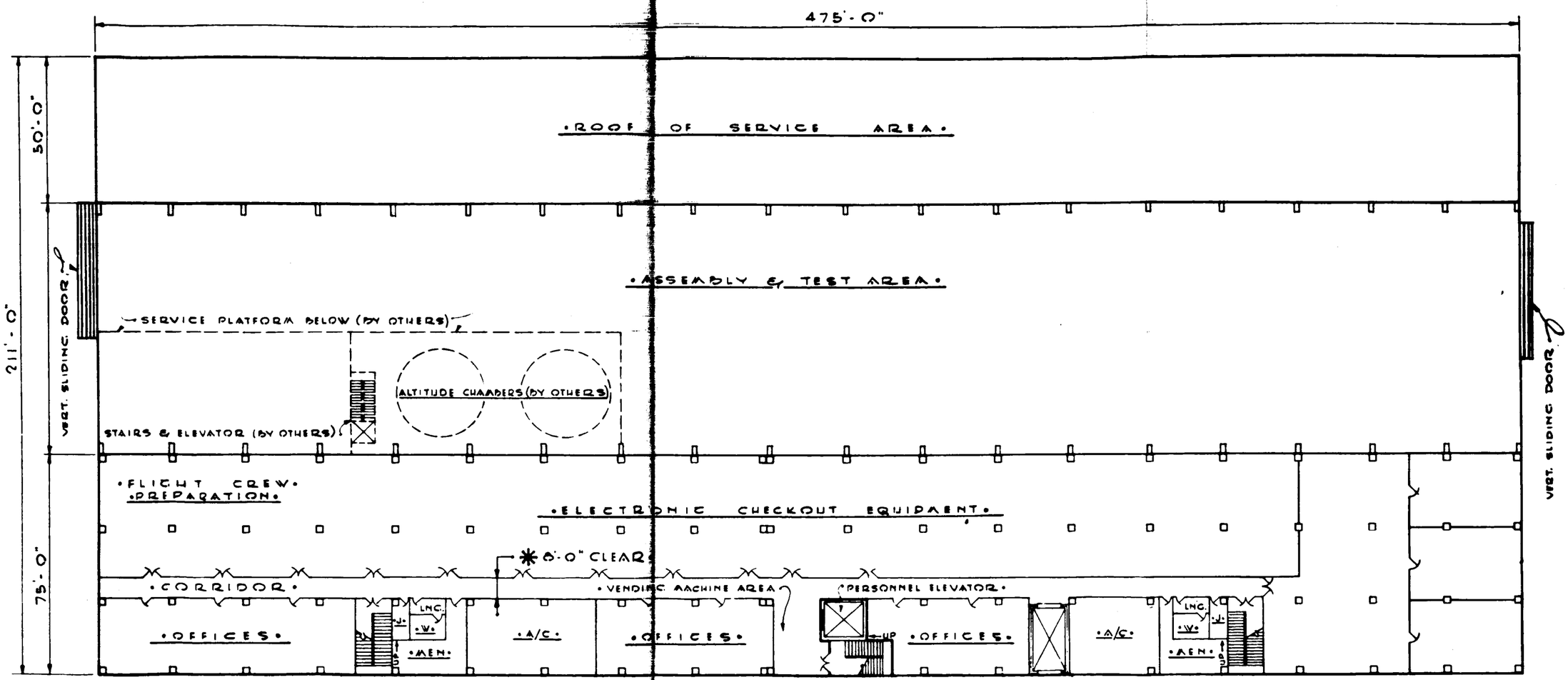



Figure 12. AMR-MSC Operations and Checkout Building - Third Floor Plan

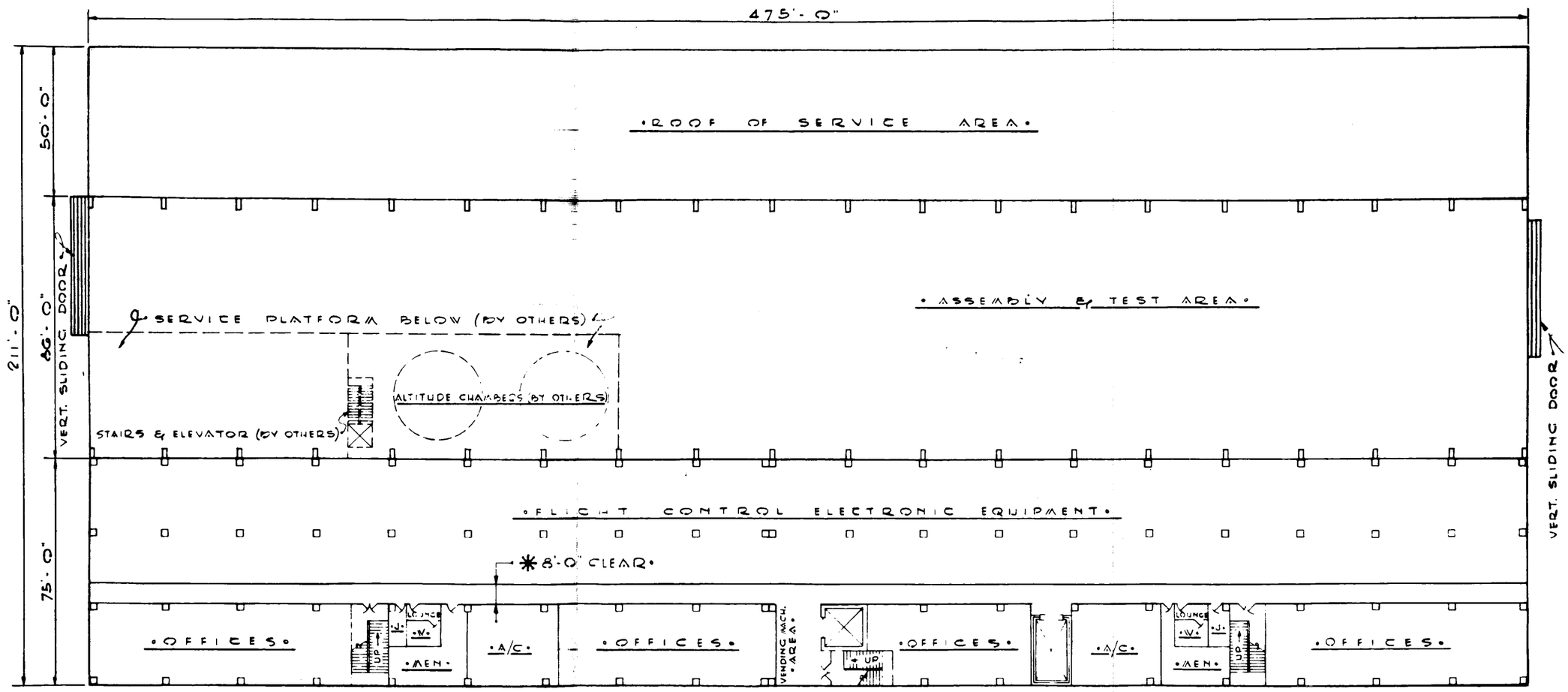



Figure 13. AMR-MSC Operations and Checkout Building - Fourth Floor Plan

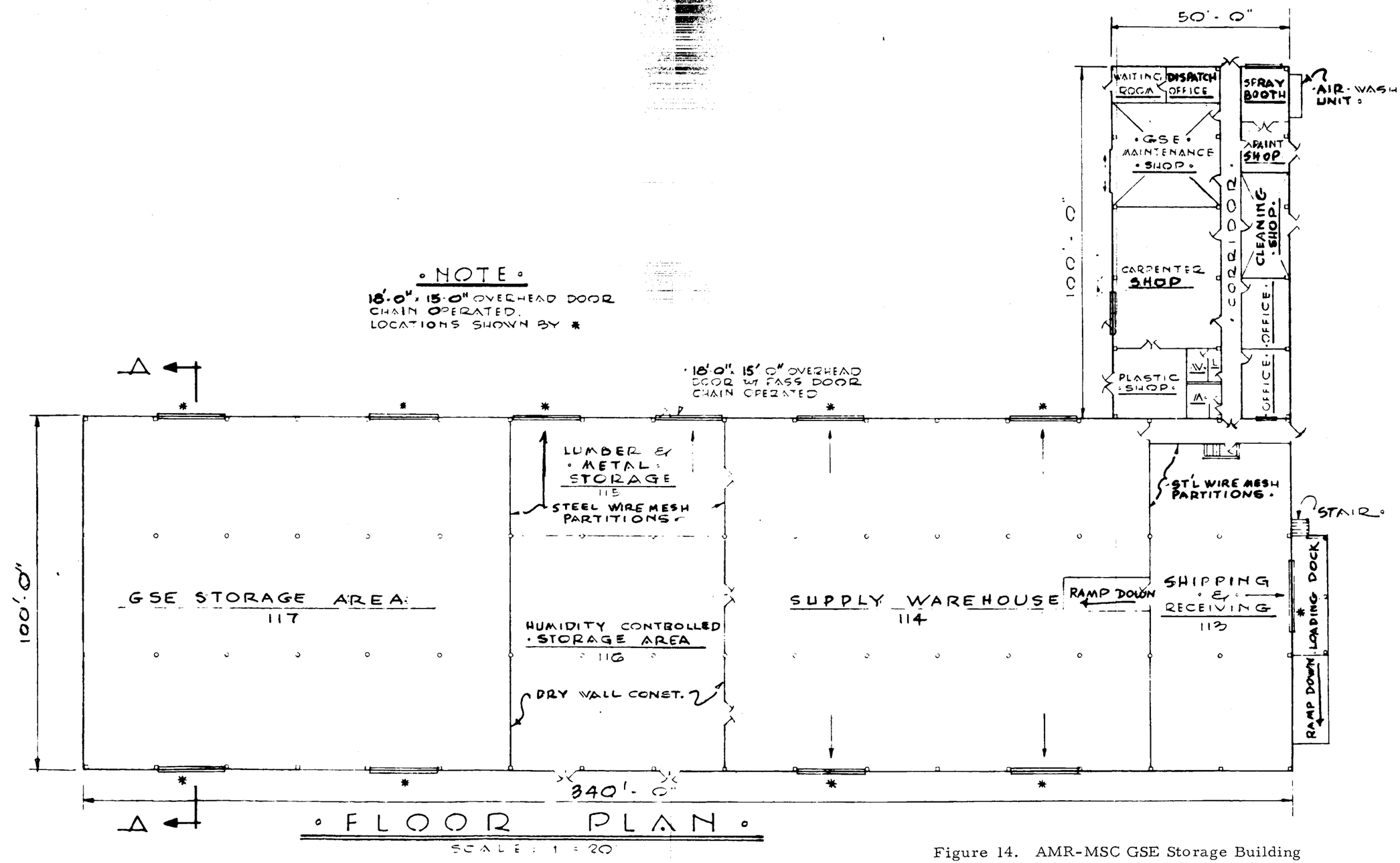



Figure 14. AMR-MSC GSE Storage Building

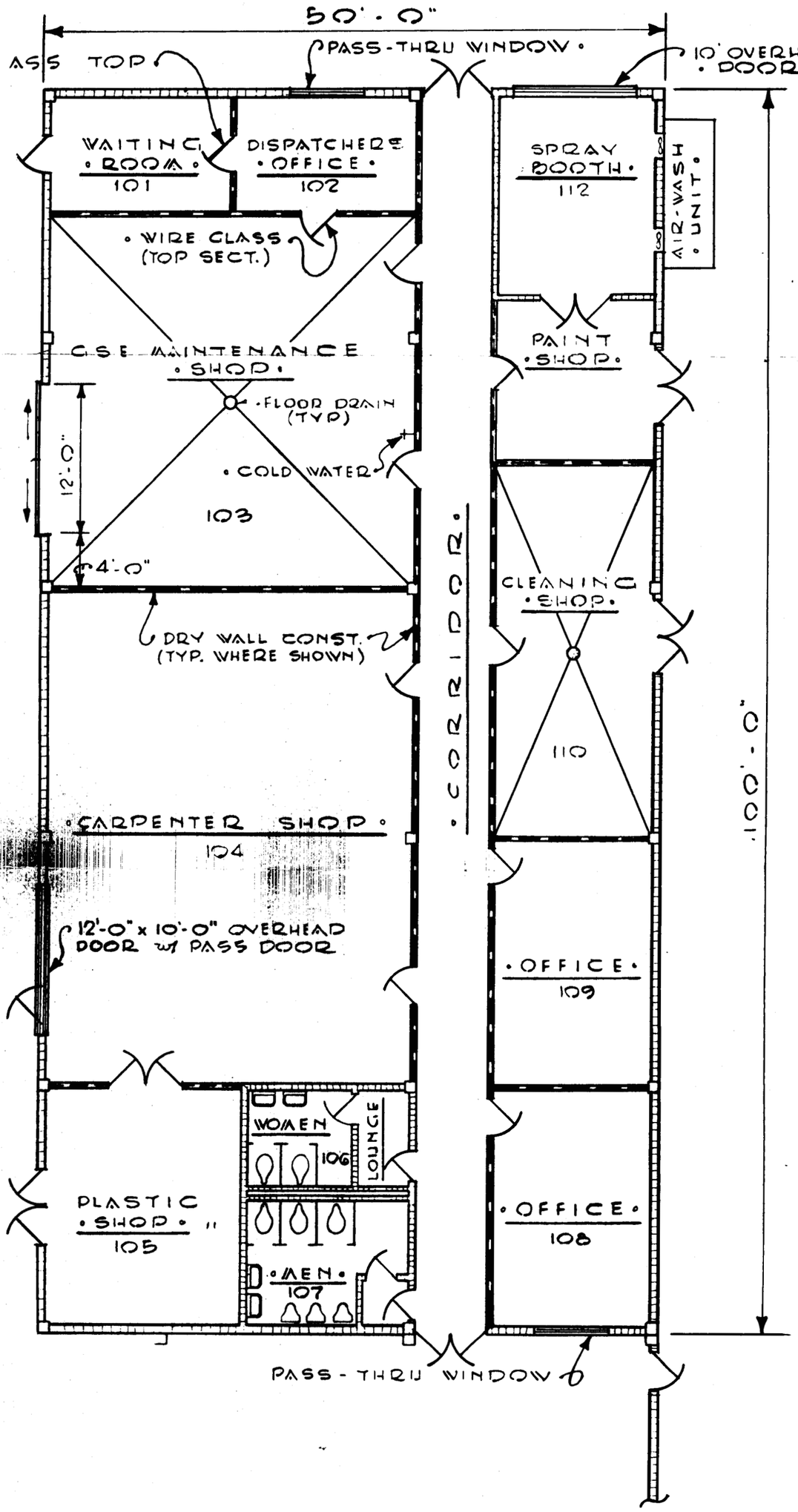



Figure 15. AMR-MSC GSE Storage Building Shop Area

35, 36

SID 62-202

CONFIDENTIAL

# MAINTENANCE DETERMINATIONS

## SYSTEMS TEST PLAN

The Apollo Test Plan, Phase A (SID 62-109), describes the manner in which the S&ID will accomplish all testing required to qualify the Apollo lunar spacecraft for manned earth-orbital flight. The test program for flights beyond earth orbit will be presented in a future document.

The planned development test integration logic, objectives, schedules, and test procedures are described in a condensed form in this report. The appendixes present completely detailed individual test plans. Presentation of information in this manner permits greater flexibility for new or revised data as the state of the art advances or as program variations occur and provides the foundation upon which the maintenance and support requirements are based.

## MAINTENANCE SUPPORT FUNCTIONAL DRAWINGS

The maintenance support functional drawings of the example boilerplate number 12, presented in Appendix A to this report, illustrates, in a logical progression, the tasks that make up the test and delineates the basic maintenance support requirements of the test program for the maintenance planner. The support factor is included in the maintenance functional drawing because support is necessary in sustaining maintenance of a spacecraft.

The first-level drawing depicts the gross maintenance/support functions required to fulfill the test objective. The drawings have been conceived from information contained in the Apollo Systems Test Plan and other related data.

The Bi-level follow-up drawings in Appendix A depict the gross maintenance needs and break down the known gross tasks required to sustain/upkeep the test and assist in determination of maintenance/support requirements.

## OPERATIONAL SUPPORT ANALYSIS

S&ID, with support from the subcontractors and through a maintenance analysis, will develop and maintain the support requirements necessary to effectively implement the test objectives.

The data resulting from the maintenance analysis of the program and systems hardware will delineate the facilities, support equipment, resources, procedures, and schedules required to support each test throughout the life of the Apollo program. These data will be utilized in the compilation and preparation of support manuals, transportation, handling, and supply requirements. In addition, the data will be utilized to document the requirements for tools, equipment, and facilities and for the determination of maintenance levels and functions.

## DATA ADMINISTRATION PROGRAM

The purpose and function of an S&ID central data group, known as the data administration group of Data Analysis Engineering, is to provide a single source for all information related to product evaluation and improvement. It will also provide a source for any information indicative of the success of application of similar or related parts or equipment by other agencies.

The information to be collected and stored will be gathered from suppliers, associate contractors, inspection, manufacturing, engineering, purchasing, test, customers, other contractors, other NAA divisions, and data exchange agencies.

### Responsibilities

It is the responsibility of Data Analysis Engineering to provide procedures and methods for data acquisition; systems for coding, classifying, categorizing, and correlating the data; definition of manual and machine data-storage and retrieval systems; definition of machines to detect and summarize unsatisfactory or incipient conditions and trends; and systems for satisfying routine and special requests for data from S&ID personnel.

### Program Description

The capability to provide complete and comprehensive information on all known experience with a particular part of equipment will significantly enhance the S&ID's ability to benefit from all prior experience. The state of the art in space research is advancing so rapidly that optimum use of the ever-increasing volume of application data can only be achieved through organized systems for machine data processing. The ever-increasing demands for higher equipment reliabilities for manned space flights of long duration necessitate more exact knowledge of equipment capabilities and the means for earlier detection of weaknesses. Data processing equipment can assist in performing these tasks more efficiently and more exactly. A single source for all related data of this nature provides management with increased visibility of the nature and scope of program difficulties and

accomplishments, as well as a valuable means of applying experience in initial design.

The program for establishment of the data management group provides for accomplishment of the various tasks defined in the following paragraphs.

Failure and Discrepancy Reporting

This system provides for the acquisition and processing of failure and discrepancy reports generated in supplier, associate contractor, inspection, manufacturing, engineering, and test areas. It includes a definition of responsibilities; the procedures for coding and submitting the information to machine data processing; a definition of machine systems used for storage and correlation; and a closed-loop system to provide analysis, test, and corrective action information to the report originator.

The failure and discrepancy report system provides for the generation of a short-form discrepancy report on all equipment removals or rejections and will also serve as a removal record in the equipment log and a follow-up report for repair and disposition information. A longer form, known as a failure and problem report, will be generated on defined failures or problems requiring further elaboration or corrective action. The long form provides for a more detailed description of the difficulty and the circumstances surrounding its discovery, allows for recommendations by the originator, and flags the hardware which requires special handling. It also provides for special test and teardown analysis. Quality Control will be responsible for generation of all long-form reports up to the time the subject item is accepted by division inspection. From this point on, the responsibility for long form generation lies with Reliability Engineering personnel.

The basic information on the short form can serve as the heading for the long form to avoid duplication; the two forms will thus cross-reference each other.

All removed parts (with short form or long form attached) will be routed to a malfunction review area for review by Reliability and/or Quality Control personnel.

The responsibility for machine processing of the reports rests with Data Analysis Engineering. The latter group will assure the satisfactory completion of both forms, although the responsibility for corrective action in any individual case rests with the originating department or with the assignee. All assignments for analysis or corrective action will be coordinated through Data Analysis Engineering, who will be responsible for timely follow-up.

A corrective action request (CAR) form will be originated on conditions or problems that cannot be adequately defined on individual failure reporting forms.

Receiving Rejection Information

A complete history of acceptances and rejections in receiving inspection is required to measure the proficiency of S&ID suppliers to produce, verify, and deliver a reliable product. It also provides S&ID with the means to detect and call out unsatisfactory hardware before installation and simultaneously permits early detection and correction of weaknesses in design or processing.

Receiving inspection personnel complete IBM cards on all incoming material. The total number received, the number rejected, and the reasons for rejection are shown. These cards will then be submitted to data processing by Data Analysis Engineering for subsequent processing, tabulation, and correlation with other relevant data.

Manufacturing Discrepancies

The recording and summarizing of manufacturing discrepancies provides a measure of product conformance with engineering and customer requirements. Consequently, the sufficiency of manufacturing and inspection techniques and the adequacy of tooling manufacturing processes and procedures are indicated. This process also serves as a useful tool for detecting and correcting unsatisfactory conditions that could degrade the reliability or quality of the final product.

All discrepancies will be recorded and submitted to Data Analysis Engineering on a daily basis to be immediately transmitted to data processing. The tabulations generated from this system will be presented in such a way as to permit ready detection of repetitive discrepancies. The system will provide for the recording of subsequent actions taken to correct unsatisfactory conditions, including references to failure and discrepancy reports or corrective action requests. It will be the responsibility of Data Analysis Engineering to assure timely correction of problems reflected in these reports.

Functional Parameter Monitoring

Extrapolation of test data obtained from systematic recording and monitoring of various functional part or subsystem outputs through successive stages of assembly and test will permit the prediction of out-of-tolerance conditions before they occur. In addition to providing assurance

of maximum reliability for the operating time of interest, such a system will detect incipient failure modes before the final, possibly catastrophic, failure of the equipment and accompanying loss of vital evidence. The system requires that allowable drift rates be established with increased operating experience; and, consequently, criteria is provided for establishing realistic replacement schedules on time-sensitive equipment.

The data of this sort will be collected in defined formats from the supplier's final acceptance test through S&ID receiving inspection, assembly test, systems checkout, all-systems test, static firing, and final flight. Timely acquisition of these data from a prelaunch firing will permit machine correlation with prior records and the establishment of go or no-go decision. Such records will provide a definitive measure of confidence in the ability of the concerned equipment to perform its mission successfully.

Configuration Accounting and Operating Time Records

A good configuration accounting system is a vital part of a data system concerned with product evaluation and improvement because it permits removal of defective parts or lots by defining their locations, confirmation of a desired configuration, and comparison of the worthiness of changes by providing a basis on which to judge the significance of failure frequencies (configuration multiplied by operating time = experience).

Operating time records are included in the configuration accounting system because of the relationship between these two factors (i. e. the operating time on a subsystem is directly applicable to the individual serialized components of the subsystem). The establishment of a complete configuration accounting system requires the assignment of uniform, standardized identification numbers to each and every part or type of material that enters the plant. This is required to permit machine audits of the data for accuracy and applicability.

The first configuration records will be generated by S&ID subcontractors and associate contractors (as spelled out in the contracts) and will accompany the material as it is received (amount of material, lot number, heat treatment, etc., will be included).

Records are subsequently generated each time material is drawn from the warehouse and at each successive stage of build-up; the records on lower assemblies will be incorporated into higher assemblies. Once the original configuration of an assembly has been reported, removals will be recorded via the failure and discrepancy reporting system. Other changes, such as EO's worked, must be reported by separate daily transmittals, which can be accomplished in conjunction with the CVR-MCR system. Data

Analysis Engineering is responsible for defining the system to acquire and machine process all these data and to produce the tabulations necessary to satisfy S&ID and NASA requirements.

The configuration requirements established by engineering change control groups will also be entered into the system to permit machine verification or exception by comparison with actual configuration records. A useful outgrowth of the configuration accounting system is its value in establishing valid spares requirements.

Prior Usage Data

In addition to providing records on S&ID experience with equipment in current use, the data center will establish and maintain a file of information on parts used in other missile and space programs.

Participation in the interservice data exchange program (IDEP) and related programs and the establishment of contracts with other contractors and NASA for exchange of data will be accomplished. These data will be available to personnel so that S&ID may benefit to the fullest extent possible from the experience of other agencies in the areas of parts application, test techniques, and failure rates.

Supplier Ratings

Supplier pre-award evaluation and surveillance are performed in order to provide assurance that the supplier has and maintains the competence required to deliver the highest quality and most reliable product available. The ratings assigned a supplier by Quality Control, Reliability, Engineering, and Purchasing are indicative of his inherent capability, cooperativeness, and consistency. Data Analysis Engineering will maintain a running record of a supplier's ratings in order to study correlations between the ratings and corresponding parts rejection and performance evaluations. This information will also be used to compare the performance of various suppliers of the same or similar parts and to seek any reflections of this in the ratings. Similar evaluations of a supplier relative to different product lines will be made.

The rating history of a supplier is a pertinent factor in the complete and comprehensive evaluation of his product. Storage of these data permit the generation of a current qualified supplier list on request.

Test Success Data

The results of all tests conducted on missile or spacecraft hardware, in terms of the degree of success or failure, is a mandatory criterion for

evaluation of product performance or conformance. Data Analysis Engineering will be responsible for the acquisition and tabulation of all such associated data in order to provide a correlation with other related information and consequent increased management visibility. These data will define the tests conducted and will be categorized in such a fashion as to tie in with data from other data systems.

Code Manual Development

The efficient machine processing of data requires the establishment of a consistent uniform system for classifying and categorizing the data transmitted to data processing. Information retrieval in a definitive manner can only be achieved if the output requirements are built into the input system. Data Analysis Engineering will provide a standard code manual to provide for machine-sort capabilities compatible with the data requirements of the various users of data within the division. The data outputs from the center as presently defined include the following:

Qualified supplier lists

Approved parts lists

Parts status reports

Trend reports (by performance or by discrepancy)

Problem summaries, status, corrective actions

Current configuration lists

Manufacturing discrepancies summaries

Complete part histories (by P/N, S/N, and type)

Lists of critical and time sensitive parts

Operating time histories

Reliability assessment summaries

Failure rate information

Material disposition summaries

In order to meet these output requirements, the following codes and sort capabilities are being developed:

Part identification:

- Part number
- Serial number
- Manufacturer
- Application identification (where used)
- Type
- Status

System and subsystem

End item and serial number

Failure reports:

- Report number, date
- Symptom
- Mode of failure (physical cause)
- Cause (basic)
- Significance
- Problem identification
- Report status

Location

Type of test

Test conditions (for sorting prior usage information)

Test parameter

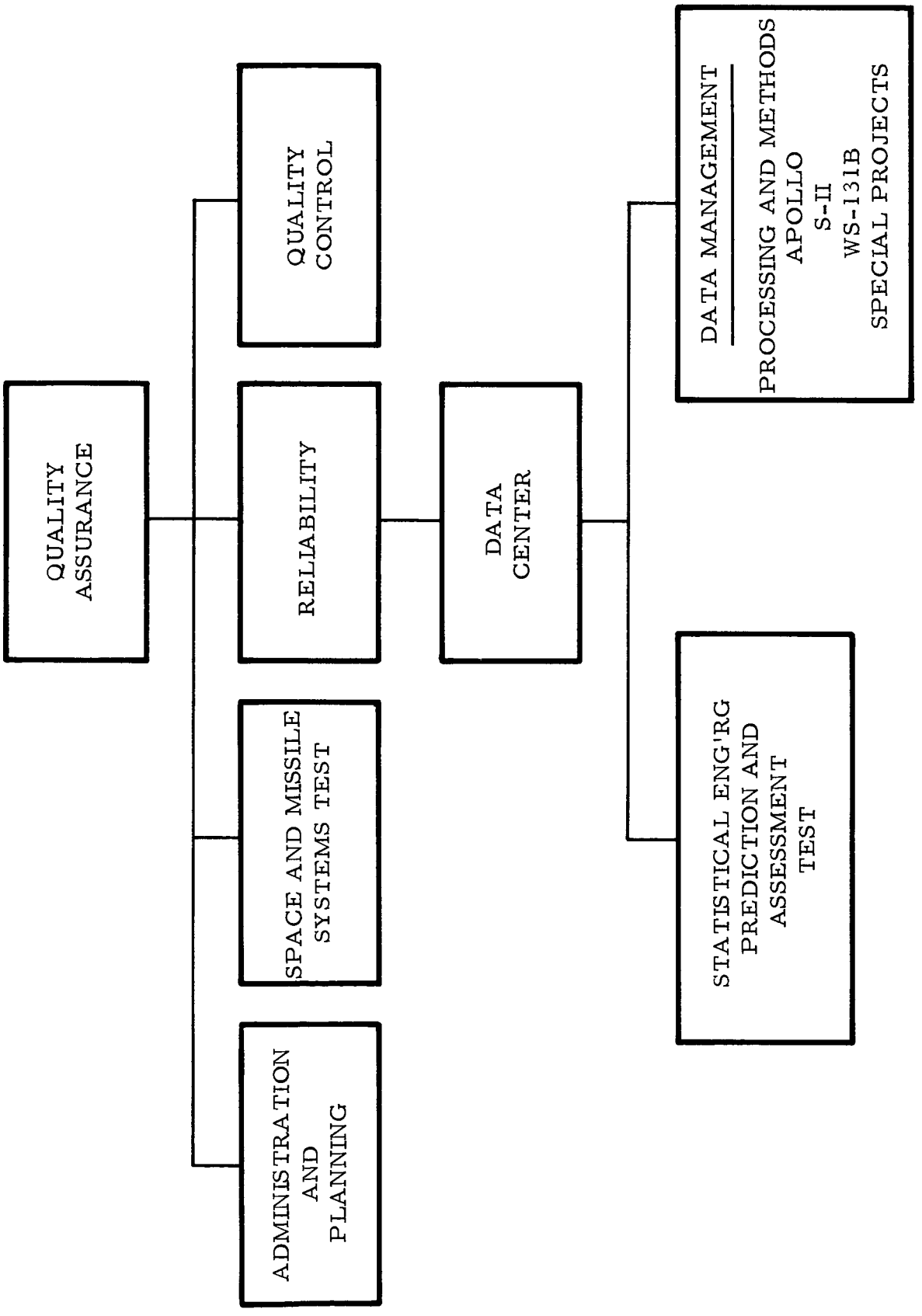



Figure 16. Quality Assurance Organization Chart

Limited-life parts (time-sensitive)

Critical parts

Log number

Material disposition

Data Analysis Engineering will provide S&ID representation in coordinating the corporate office discrepancy code standardization program.

Basic Part and System Information

Certain infrequently generated data will be included in the data system for reference purposes. These data provide the basis for comparison runs and for special listings and include the following:

Critical and time-sensitive parts definitions

Parts status and category

Reliability requirements, predictions, assessments

Application information

Organization

The data Management group occupies the position in the S&ID organization as indicated in Figure 16. The Director of Quality Assurance reports to the President of the Division.

## CONFIGURATION CONTROL

The principal purpose of a configuration control system governing maintenance during factory testing, storage, assembly, and prelaunch testing is to impose necessary control requirements on the equipment or equipments used to repair or modify as assembly, subassembly, system, subsystem, or component. These controls are imposed to ensure the use of the most optimum components from the standpoint of reliability, interchangeability, function, compatability, and maintainability. Defined here is a coordination activity with the change control section for review and documentation of all modification or changes to the Apollo Program. This activity will ultimately result in absolute control and uniformity of all Apollo vehicles.

In order to implement the necessary control requirements, configuration control documents will be formulated to restrict the parts, components, or hardware used to modify or repair any system, subsystem, assembly, etc., installed on the Apollo vehicle or GSE. These configuration control documents will delineate the major areas of configuration control, compatability and interchangeability.

Compatibility

To maintain absolute compatibility of the systems, subsystems, and components installed, certain information must be provided. This information will be a part of the configuration control documents and will display compatible and noncompatible equipment and/or components. This compatible and noncompatible equipment will be defined by part number; description; lot or batch number; and, if possible, serial number.

Interchangeability

Interchangeability information will encompass a major portion of the configuration control documents. This data will be displayed as one-way and two-way interchangeability, thus defining acceptable replacement parts, components, or hardware. Traceability is one of the paramount functions in maintaining a system or subsystem in operable condition. If a system or subsystem is rendered inoperable because of poor reliability or faulty manufacturing, the capability of tracing back to raw materials or locating all like parts (same part number or lot) for corrective action or retest is mandatory. This can be accomplished through the use of the configuration control documents. These documents in conjunction with compatibility and interchangeability data will record the source of supply to provide traceability.

The preceding requirements, although generally defined in this text, will be utilized by Apollo Quality Control, Test, and Manufacturing personnel in developing a space vehicle capable of successfully attaining the objectives of the Apollo Program.

## MAINTENANCE RESPONSIBILITY

As prime contractor, S&ID is responsible for the Apollo spacecraft configuration, systems, associated (GSE), and maintenance at all operational sites, including the AMR.

The maintenance effort shall include the up-dating and modification of the spacecraft or systems the repair or replacement of out-of-tolerance or malfunctioning parts or components and the scheduling and conducting of routine or special checkout operations to verify spacecraft and systems performance to specifications. The S&ID maintenance responsibility also includes the establishment of various engineering laboratories, machine shops, tool cribs, and other resources required to sustain the spacecraft operations.

Spacecraft and associated support equipment will be maintained in accordance with standard S&ID operating procedures. Specific procedures relating to the documentation and accomplishment of engineering acceptance, configuration control, maintenance, modification, repair, checkout, and test of Apollo spacecraft and associated equipment will be incorporated in the S&ID Policies and Procedures Manual at the earliest possible date.

# MAINTENANCE ANALYSIS

## OPERATIONAL SUPPORT ANALYSIS

### Supported Events

Events to be supported include all boilerplate test activity, all subsequent prototypes, the Apollo manned spacecraft lunar landing, and the recovery mission.

S&ID, associate contractor and subcontractor milestones are included in evaluating overall support of those events that are comprised by the Apollo Program. A systematical breakdown of major events through the test article and test and maintenance cycles at a given site will ensure maximum support.

### Time, Location, and Support Criteria

Support criteria include the schedule of events and the area, facility, or site where an effort is conducted relative to the Apollo Program. Support criteria is established through the consideration of maintenance areas, prevalent environmental conditions, test article systems, subsystems, module analysis, and maintenance criteria. Apollo Program forms and documents will reflect time, location, and support criteria.

### Operational Systems Functional Analysis

The functional analysis of a boilerplate and/or Prototype activity relative to tasks or subtasks ultimately leads to support requirements. Tasks and/or subtasks are delineated in the manner consistent with economical and efficient test and maintenance practices, which are based upon knowledge gained in past R & D and on production. Contracts plus a new scientific approach to the problems associated with current space programs, Flow (block) diagrams will be prepared and furnished as a logistical guide.

### Operational Systems Requirements and Limitations

The resultant factual data compiled at the conclusion of the analysis previously described will define requirements and limitations relative to the test article (command module, space capsule, service module, escape towers), GSE, and support for support equipment plus simulators

and training equipment. Hardware design characteristics, configurations, and capabilities will be the governing factors in establishing systems (and support) parameters and limitations.

Support Systems Functional Analysis

The functional analysis of subtasks will outline, in a narrative form, the problems relative to system support at a specific facility, test site, or other area. The narration will reflect individual hardware requirements ultimately leading to support level definitions. The problems associated with support systems will be further analyzed until a realistic solution to each problem has been defined.

Maintenance Functional Analysis

The functional analysis of each boilerplate and Prototype, site, facility, cycle of events, and equipment required will be performed in order to establish gross maintenance requirements. The analyses will be made prior to further evaluation and subsequent determinations of levels of maintenance, policies, supply requirements, support manual data and the eventual equipment, personnel, special facilities and tools, etc., required to efficiently support the program in a flexible and timely manner.

Maintenance and Support Functional Block Diagrams

Functional block diagrams will be prepared and furnished to reflect maintenance activities at various sites and facilities. The diagrams will be laid out in a flow pattern indicative of efficient and economical maintenance practices.

Maintenance Requirements and Limitations

The resultant factual data compiled at the conclusion of the analysis previously described will generate maintenance requirements. Limitations will be established through available hardware design, systems operating parameters, available facilities, transportation modes, environment, time, and back-up data (drawings, specifications, microfilm, etc.).

Equipment Requirement Analysis

GSE required at each facility, tools, and special requirements will be designed, fabricated, and procured as required. All GSE (test equipment, handling equipment, servicing equipment, and auxiliary equipment) will be documented in appropriate format in consonance with Apollo Program directives. In addition, equipment required to support GSE end items will be documented.

In order to provide a useable report, peculiar and non-standard and common and standard equipment will be reflected in the same document, where possible and as applicable.

Equipment Maintenance Analysis

Categories of equipment delineated in the requirement analysis will be screened for applicability to the Apollo Program. In order for this equipment to efficiently support those systems for which it was intended, little down-time can be allowed. Consequently, an analysis of design, operation, limitations, and maintainability features directly affecting down-time, service life, and spares will be conducted. Compatibility with other equipment and test articles will be designed into test equipment, handling equipment, servicing equipment, and auxiliary equipment. Maintenance equipment presently in Government inventory will be utilized whenever possible.

Equipment Recommendation Data

S&ID will prepare and submit to NASA, on a progressive basis, equipment recommendation data reflecting the best estimates as to types and quantities of GSE (peculiar and common CFE). Information pertaining to manufacturing and procurement load time will be included as a means of providing data for planning, programming, and budgeting purposes. Such data shall be up-dated and submitted in a timely manner to assure proper logistic and maintenance support of the overall Apollo Program.

The maintenance concept of the Apollo Program is to parallel support of test efforts and overall technical development of the Apollo spacecraft with a flexible and ever-improving approach to maintenance and maintainability. Ability to circumvent design deficiencies is of prime importance in any program wherein the time element is of a nature so critical as in the Apollo Program. Consequently, reliability is being designed into test articles and GSE to the extent that maintainability problems will be at a minimum and the ability to sustain in the field will be at a maximum.

REPARABLE ANALYSIS

A reparable analysis shall be conducted of spacecraft and GSE furnished by S&ID and subcontractors for the Apollo Program. The analysis will define the scope of repair, overhaul, and modification by determining the level of rework to be performed on components that are damaged, malfunctioned, or obsolete. To obtain this objective repair, overhaul, or modification of S&ID or subcontractor components will be accomplished

by close coordination between S&ID Apollo departments and subcontractors or their representatives in the following areas:

Participation in the repair, overhaul, and modification program

Sufficient repair capabilities existing within the manufacturing department

Ascertain if an expeditious turn-around-time can be complied with

Inform subcontractors of required reports (i. e., parts usage, failure analysis reporting, delinquency, etc.)

Apprise the subcontractor of limitation of design changes to minimize modification programs and maintain quality assurance

Past experience has proven that repair, overhaul, and modification requirements are considerably different than during the original production of a component. One of the main objectives of the reparable analysis will be to determine these differences and to ensure that the necessary techniques, facilities, and skills are available. This will ensure that original reliability standards will be maintained.

To maintain the necessary high degree of reliability required for the Apollo project, the reparable analysis will assist in determining the repair, overhaul, and modification requirements. As in the case of vendor-supplied components, the analysis will indicate which components will require corrective action beyond the capabilities of the S&ID repair, overhaul, and modification section.

Requirements

Provisioning documents, drawings, and parts breakdowns shall be analyzed to determine interchangeable and replaceable S&ID or subcontractor items to reduce repair, overhaul, and modification turn-around-time.

The shop release method shall be employed to support the procurement and/or manufacturing of S&ID or subcontractors spare parts. This operation shall authorize manufacturing or purchasing to go ahead by actual need dates for concurrent delivery.

To ensure fast preselection for lead-time dates and documentation, an analysis of components for repair, overhaul, and modification will be

required (Figure 17). This analysis will be based on items considered not reparable at a test site.

Overhaul Analysis Documentation

The overhaul analysis will provide interchangeable and replaceable information regarding S&ID or subcontractors components, parts, modules, etc., that will be included in support manuals and assist in determining the repair level of affected items.

The overhaul analysis of S&ID or subcontractor components will indicate any particular assembly, component, part, module, etc., that may possibly serve more than one support level.

A comprehensive and accurate reparable analysis will reveal potential problem areas in time to avoid costly delays in the repair, overhaul, and modification cycle. The overhaul analysis will consider each assembly/module item of equipment and will determine the following requirements for repair, overhaul and modification.

Test

The test, or series of tests in which a specific item will be used.

Support Period

The support period is the period in which an item will be active. The support period will be considered ended when the item is no longer useful to the program.

Reparability

The reparability of an item and the feasibility, from an economical standpoint, to repair the item will be determined.

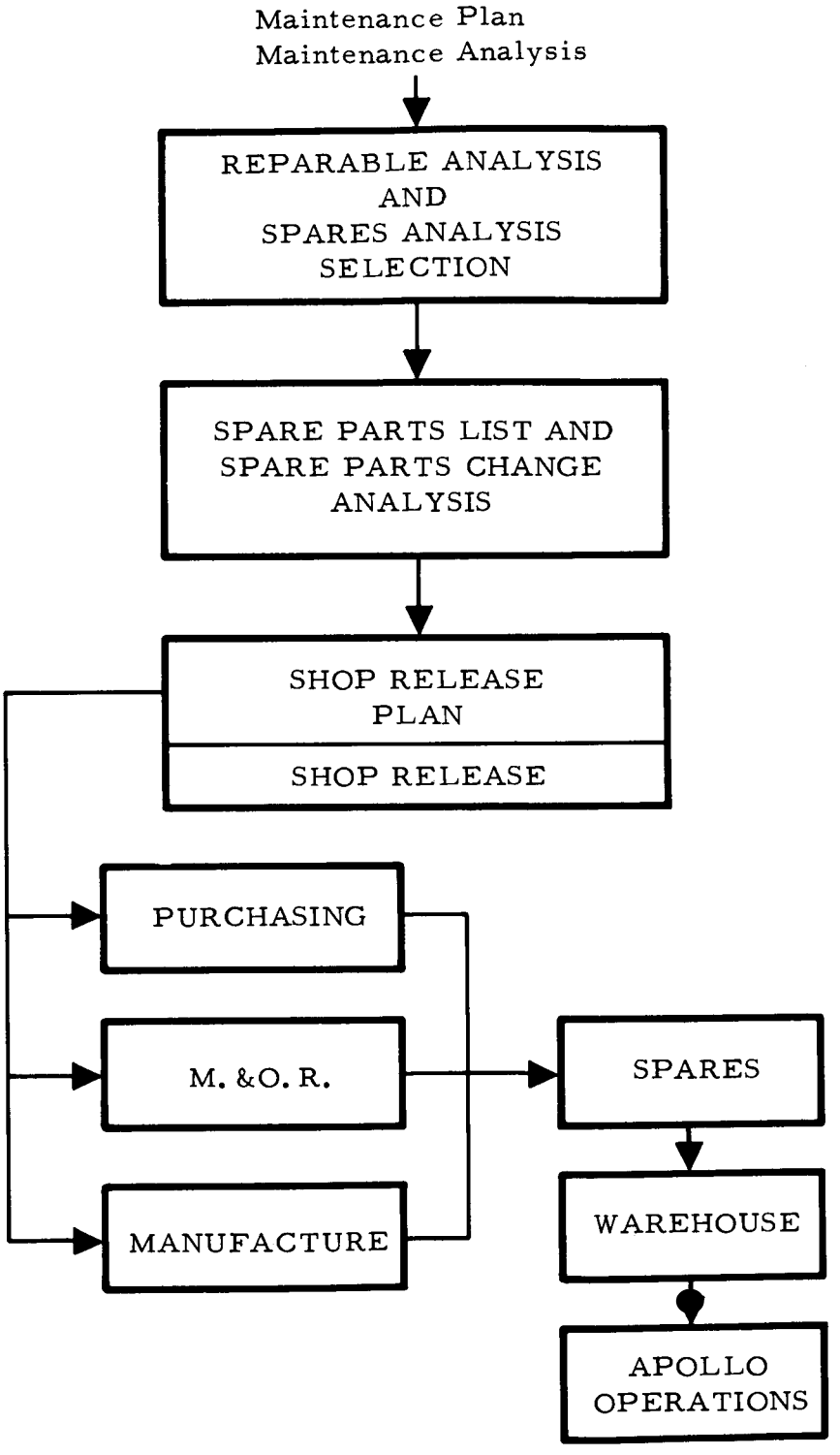



Figure 17. Reparable Component Analysis Flow

Location

Where the item will be repaired, and the possibility of repairing the item at the test site will be determined. The repair will be verified using checkout level GSE, and if decision as to whether the item must be returned to the factory or a vendor will be made.

Responsibility

S&ID will determine the prime responsibility for the repair of the item as prime contractor. S&ID will be responsible for most repairs; however, due to the complexity and lack of suitable test equipment at S&ID some items must be returned to the vendor. Equipment owned by NASA or DOD will be considered to determine S&ID's obligations and limitations.

Repair Level

Where the item can be repaired, will be determined. The analysis will determine if it is feasible to repair the item while it is installed in its ultimate system. For example, a drawer-type module could be opened on a console; and the repair could be made on the spot. An example of a subsystem repair would be a drawer type module that must be removed from its console to be repaired, but the drawer would not have to be disassembled. Bench-level repair requires disassembly to the component level or lower. This section of the analysis will also reveal any adjustment or calibration requirements.

GSE

The type of GSE required to repair or verify the repair of an item will be determined. This area of the analysis will consider all available GSE from first-level checkout consoles down to and including special bench-level equipment.

Environment

Special environmental conditions that must be met to repair the item will be determined. This portion will analyze the item to determine if the item is affected by humidity, dust, temperature, pressurization, or any other special environmental conditions.

Mean Time Between Failure

The analysis will research each item to determine when it must be replaced. To arrive at this conclusion, a multitude of factors must be considered. Amoung these factors are the following:

1. Steady-state or intermittently operation
2. Determine if the useful life of the item is established by time or by cycles of operation
3. Determine if the time or number of cycles is recorded in a log or automatically recorded by a meter or clock.

Repair Support Factors

In this area the analysis will consider the following support factors:

1. Technical data, such as drawings, and specifications of support manuals required to accomplish the repair, overhaul, or modification
2. Level of skill required, engineer, skilled technician, or mechanic
3. Special overhaul kits or modification kits required
4. Special tools required
5. Special handling of the item required

Effectivity

The analysis will consider each item within the assembly/module to assure that the repaired, overhauled, or modified assembly/module is compatible with its end item.

Interchangeability

This area of the analysis will consider every possible use for the item. For instance, an item could be used on several pieces of GSE, the spacecraft, and a trainer.

Shelf Life

The analysis will reveal the shelf life of each module/assembly by determining the shortest life-time item within the assembly/module.

Such factors as cure dates on rubber parts and packaging limitation will be considered.

Lead Time

A detailed analysis of each item required to build up the assembly/module will be conducted to determine its lead time. A strong emphasis on this area will avoid costly delays in the program by anticipating long lead time items.

Repair Time

The analysis will estimate the actual man hours required to overhaul or repair the affected assembly/module. This information is needed to determine the overall turn around time for the item.

Data needed for the reparable analysis will be supplied by the responsible S&ID activity and compiled in a single document. The resulting analysis will be disseminated to all functional organizations concerned.

# APPENDIX A

## MAINTENANCE SUPPORT FUNCTIONAL FLOW DRAWINGS FOR BOILERPLATE NO. 12

1.0 Systems Test Receiving Operations.

1.1 Inspect and Verify.

Inspection and verification will be primarily an in-house function consisting of a complete acceptance inspection and transfer of custody of the test articles from the Manufacturing Department to the Systems Test Group. Deficiencies and complaints will require recycling of the affected test article.

1.2 Documentation and Storage.

Documentation of complete inspection, acceptance and configuration verification occurs at this point. In the event system test operations must wait on an unavailable test article, adequate storage facilities will be provided.

2.0 Precheckout Operations.

2.1 Update and Modify Test Articles and GSE.

Engineering changes will be incorporated in the test articles by systems test personnel in the systems test area.

Test articles will be modified to accept instrumentation and telemetry equipment.

Test support equipment will be updated and modified to maintain system compatibility, and interface relationships.

2.2 Install Instrumentation and Telemetry Equipment.

Instrumentation sensors and pickups will be installed to monitor the test. Converters, antenna, and transmitting equipment will be installed. Cabling will be routed and connected and installations will be tested, verified and documented. Maintenance support of this effort will be supplied by the Bench Maintenance Area.

3.0 Verify Structural Interfaces.

3.1 Mate and Fit-check Test Articles.

Major test articles, the boiler plate, the launch escape tower, and the service module adapter will be physically mated, fit-checked and aligned. Structural interfaces are verified and modifications accomplished as required.

Major assembly interfaces will be verified, the launch escape motor, tower Jettison Motors, Etc.

3.2 Weight and Determine the Center of Gravity.

The test items will be weighed and the center of gravity determined. The test articles will be ballasted and modified to obtain the weight and center of gravity configuration of the prototype. Special tools will be used as required.

4.0 Systems Verification.

4.1 Checkout Basic Systems.

The basic systems will include those under test and those in a supporting role. Each system will be checked out for system integrity and for proper operation.

Systems which will be under test include the launch escape systems and the launch escape motors. Stabilization, separation, radio command and tower jettison are also systems which will be under test, along with the program sequencer, electrical power and support systems.

Environmental control will be supplied.

4.2 Checkout Instrumentation and Telemetry Equipment.

A complete separate checkout of the instrumentation telemetry systems and the ground telemetry communications and data recording equipment will be conducted. The systems will be checked for integrity and operation. Interface compatibility between the ground and spacecraft equipment will be confirmed.

[redacted]

4.3 Combined Systems Test.

All systems, ground and boilerplate, will be operated concurrently and sequentially as required to simulate a test launch. Verification of all system operations and system interfaces will be substantiated.

5.0 Disconnect Close-Out Test Articles and GSE.

Shut down all equipment; disconnect and show cables; close-out and prepare GSE and test articles for packaging by sealing openings, etc.

5.1 Special Handling and Packaging Requirements.

All special handling and packaging requirements will be established to guide Material Services.

5.2 Documentation

Documentation of close-out procedures will be completed. Transfer of custody of test articles, GSE and miscellaneous equipment to Material Services for packaging and transportation to the test site will be executed.

6.0 Materiel Services.

6.1 Packaging and Storage.

Provide packaging for test articles, GSE ER. Provide special environmental and shock attenuation packaging as required. Storage facilities, including environmental controlled storage, will be provided.

6.2 Traffic.

Arrange and schedule DOD transport as required. Provide transport to the DOD terminal site.

6.3 Provide Transportation.

NAA and commercial transportation will be arranged to the test site.



[redacted]

7.0 Test Site Receiving.

7.1 Receive and Inspect.

All articles and systems received at the test site will be uncrated. Remove protective covering and materiel, and clean and uncover all equipment. Complete receiving inspection will be performed.

7.2 Document and Store.

Documentation of all discrepancies and damage will be required. Documentation of custody change of all test articles and GSE will be made.

8.0 Hangar Checkout.

8.1 Update, Modify and Repair Test Articles and GSE.

Updating and repairing all test articles, GSE and related equipment to conform with latest engineering information and configuration will be performed.

9.0 On Site Transportation.

9.1 Transport Test Articles, Simulators, GSE to the launch pad and Block House Site. Transport operation will be followed by installation and hook-up of GSE and preparation of erection of test articles on the Booster Vehicle.

10.0 Pre-Launch Operations

10.1 Time phasing of the test will have the booster in position and awaiting the test articles. The boilerplate and adapter will be mated to the booster. Final interface adjustments will be completed.

10.2 Mate the launch escape tower assembly to the boilerplate. Final structural adjustments, alignments completed.

10.3 Checkout Basic Systems.

Service and checkout all basic systems for system integrity and proper operations.

10.4 Checkout instrumentation and telemetry systems.

Complete an individual check-out of the instrumentation, telemetry communications and data recording equipment. The systems are checked for system integrity calibration, operation and operational interface with the Ground and Airborne Test Article Equipment.

10.5 Combined Systems Test.

All systems are operated concurrently and sequentially as required to simulate a test launch. Verify all systems operation and system and vehicle interfaces.

10.6 Final Servicing of all Systems.

10.7 Install and Connect all Pyrotechnics.

Connect all control circuitry to the motors. Install and connect and squib and separation devices.

11.0 Launch

Coordinate with all airborne, seaborne and ground reconnaissance, camera, observer, and pick-up vehicles and facilities. Countdown and launch. Monitor all performance, data communications, and recording indicators.

12.0 Recovery Operations.

Coordinate with air and seaborne recovery vehicles. Complete pick-up and transport of test vehicle to pre-determined test site for post test operations.

13.0 Materiel Services

13.1 Provide storage and packaging for test articles, GSE, etc.

13.2 Transport as required.

14.0 Posttest operations at S&ID (Downey).

14.1 Evaluate data and test results.

14.2 Evaluate GSE, spares, etc., for disposition.

14.3 Storage, salvage, etc.

NOTES



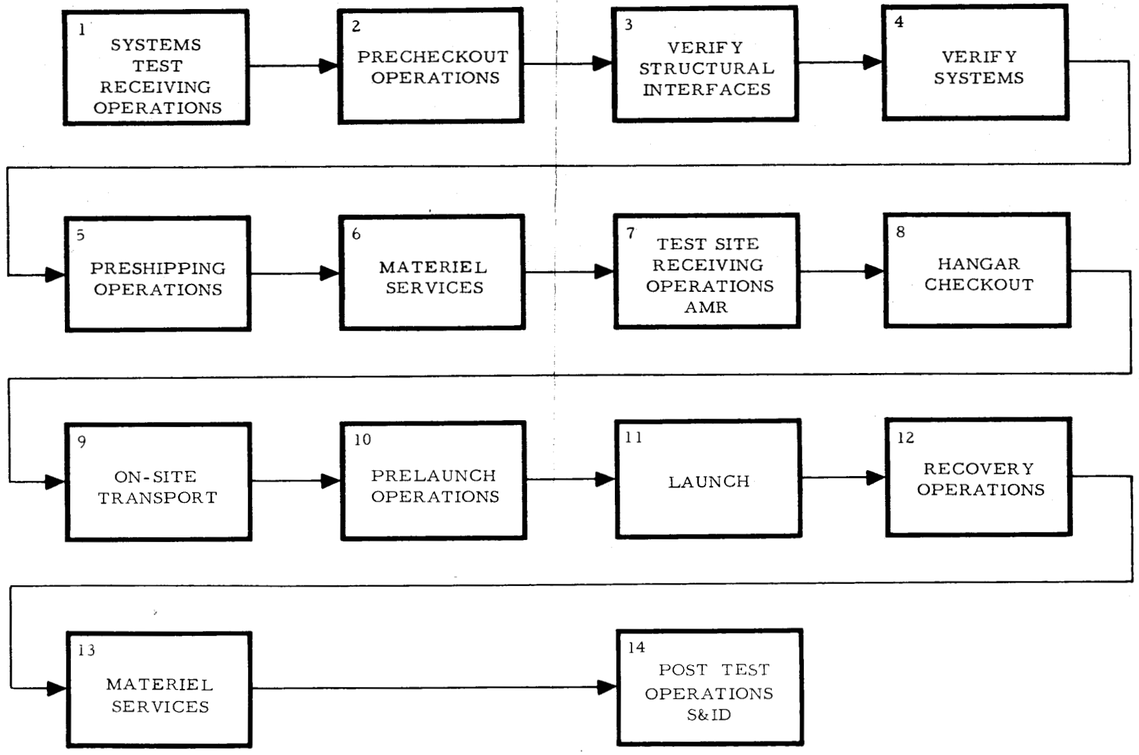



Figure A-1. Maintenance Support Functional Flow Structure - Gross

BOILERPLATE #12
LAUNCH ESCAPE SYSTEM TEST

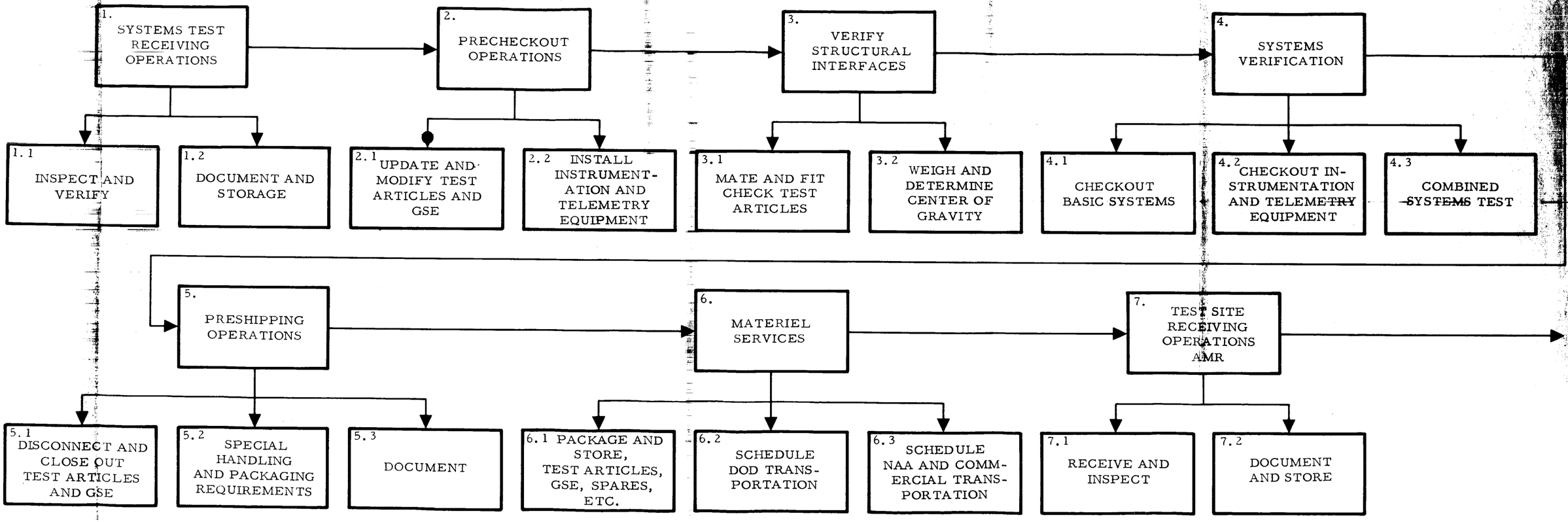
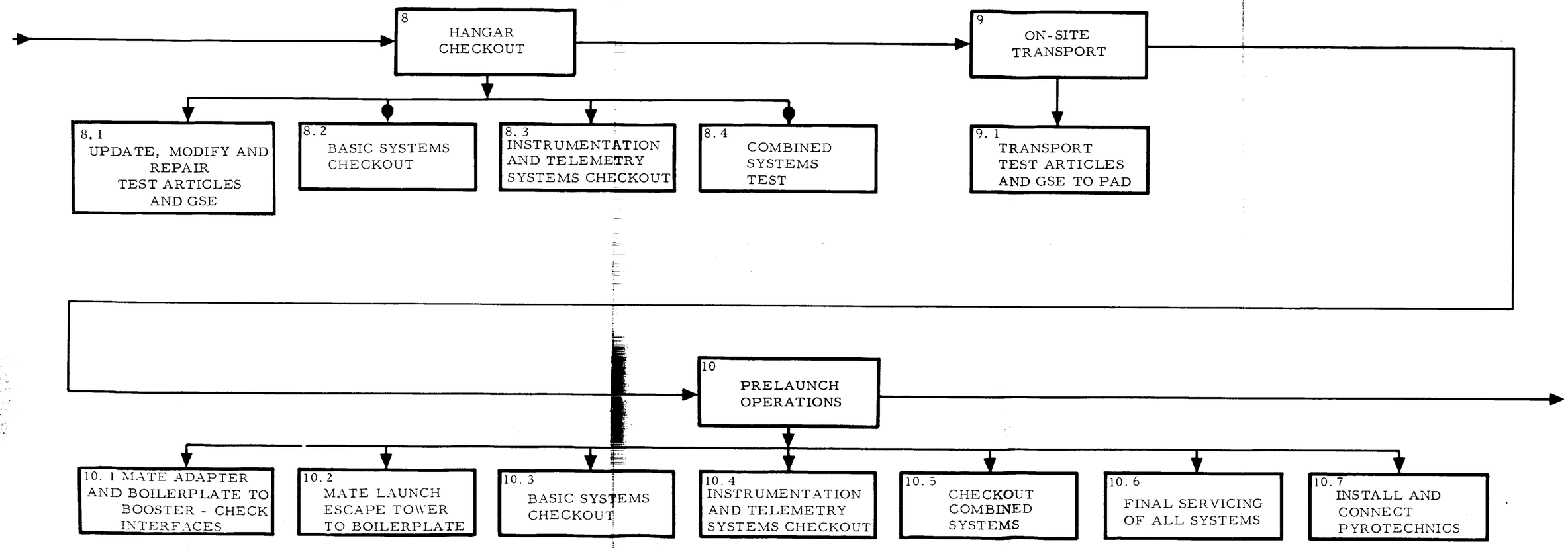

1. SYSTEMS TEST RECEIVING OPERATIONS
2. PRECHECKOUT OPERATIONS
3. VERIFY STRUCTURAL INTERFACES
4. SYSTEMS VERIFICATION
1.1 INSPECT AND VERIFY
1.2 DOCUMENT AND STORAGE
2.1 UPDATE AND MODIFY TEST ARTICLES AND GSE
2.2 INSTALL INSTRUMENTATION AND TELEMETRY EQUIPMENT
3.1 MATE AND FIT CHECK TEST ARTICLES
3.2 WEIGH AND DETERMINE CENTER OF GRAVITY
4.1 CHECKOUT BASIC SYSTEMS
4.2 CHECKOUT INSTRUMENTATION AND TELEMETRY EQUIPMENT
4.3 COMBINED SYSTEMS TEST
5. PRESHIPPING OPERATIONS
6. MATERIEL SERVICES
7. TEST SITE RECEIVING OPERATIONS AMR
5.1 DISCONNECT AND CLOSE OUT TEST ARTICLES AND GSE
5.2 SPECIAL HANDLING AND PACKAGING REQUIREMENTS
5.3 DOCUMENT
6.1 PACKAGE AND STORE, TEST ARTICLES, GSE, SPARES, ETC.
6.2 SCHEDULE DOD TRANSPORTATION
6.3 SCHEDULE NAA AND COMMERCIAL TRANSPORTATION
7.1 RECEIVE AND INSPECT
7.2 DOCUMENT AND STORE

Figure A-2. Maintenance Support Functional Flow Structure - Task Identification (Sheet 1 of 3)

BOILERPLATE # 12
LAUNCH ESCAPE SYSTEM




MAINTENANCE SUPPORT FUNCTIONAL FLOW (TASK IDENTIFICATION) STRUCTURE (SHEET 2 of 3)

Figure A-2. Maintenance Support Functional Flow Structure - Task Identification (Sheet 2 of 3)

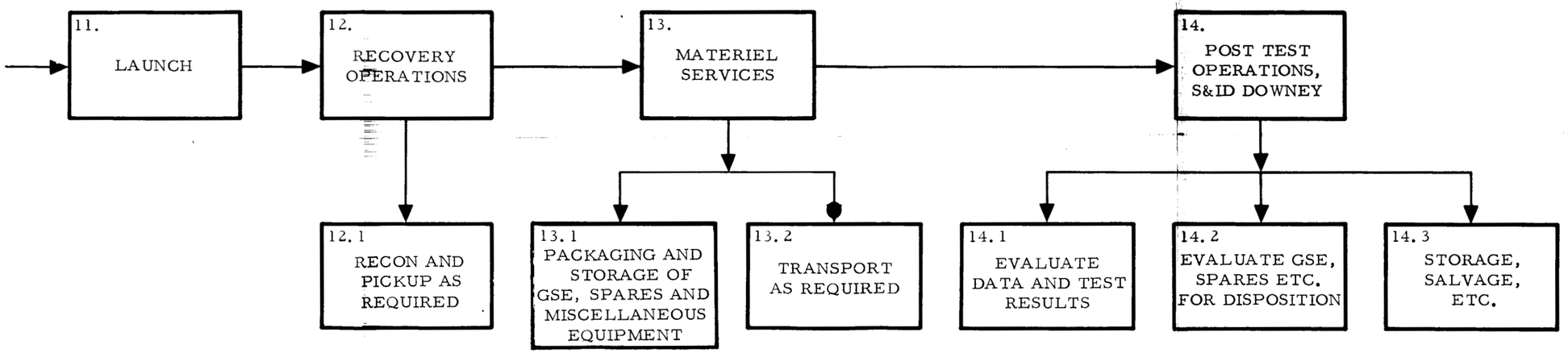



Figure A-2. Maintenance Support Functional Flow Structure - Task Identification (Sheet 3 of 3)

# APPENDIX B

## GLOSSARY

| | |
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| Abort | An abort is an uncompleted missile flight or hold-down test resulting from a failure of any equipment or system other than the one undergoing test. |
| Acceptance Test | An acceptance test is a test performed on any system or equipment to insure that all specifications for that system or equipment have been met. |
| Accessible | As applied to spacecraft or GSE or ground operation support equipment, capable of being seen, grasped, removed and adjusted in place, as required. |
| Active Component | Any component of a system which provides a measurable output when operating, such as solenoid valves, amplifiers, etc. |
| Additional Instrumentation | Variable instrumentation pertaining to the engine or vehicle for a particular use in addition to "fixed instrumentation", which is common or standard for all uses. |
| AMR | Atlantic Missile Range. |
| Assembly | The term assembly is used to denote a complete functional item including a panel, chassis, and mounted components, designed to be replaceable in a unit. A working unit which contains one or more components such as resistors, diodes, relays, etc. (black box). |
| Assurance Tests | Tests conducted on all items of equipment to ensure that high standards of quality are maintained. These tests consist of (1) source and receiving inspection, (2) inprocess inspection, and (3) acceptance testing. |

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| Automatic Ground Control Station (AGCS) | Stations located near the Launch Control Center (LCC) and vehicle. Contains primary ground power sources, terminal distributors, and automatic ground equipment necessary to operate the vehicle systems remotely from the LCC. |
| Auxiliary Equipment | Those miscellaneous items of GSE not categorized as handling, servicing, or checkout equipment. Includes covers, plugs, access platform closed circuit television, etc. |
| Block Diagram | A line drawing with block outlines to designate units of functional groups for general arrangement studies, functional explanations, product familiarization, etc., within a system set or item. |
| Boilerplate (B/P) | A boilerplate is a simulated module for predevelopmental and developmental tests leading to the design of a prototype module. The boilerplate will simulate prototype module physical characteristics as required for scheduled tests. |
| Booster | The individual stage used to boost, accelerate, or lift the vehicle. |
| Cable Interconnect (CID) Diagram | An electrical block diagram showing routing of cables, connecting assemblies, subassemblies, and components. |
| Calibration Tests | Tests to determine the output characteristics of a measuring device, component, or assembly and to verify that the characteristics are within specifications. |
| Caution Light | A caution light is a placard light used to inform the crew members of an impending dangerous condition requiring attention but not necessarily immediate corrective action, such as ELECTRICAL COMPARTMENT OVERHEATED or CABIN PRESSURE LOW. |

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| Command Module (C/M) | A term describing the section of the spacecraft containing crew quarters and controls, guidance, communications, launch escape, environmental control systems, etc. |
| Common Items | Those items that apply to two or more systems, subsystems, or support equipment, including components or spares related thereto. |
| Component | A combination of assemblies, subassemblies (units), or parts which may function independently of, or as an independent entry within a complete operating subsystem but providing a self-contained function necessary for proper subsystem and/or system operation. |
| Component Part | The term "component part" will be used to denote a portion or part of an assembly that is replaceable. |
| Console | The term is used to denote a short sloping front frame, upon which standard 19-inch or 24-inch panels are mounted. The basic frame of a complete console assembly. Operable panels are sloped for operator convenience. |
| Console Assembly Complete | An assembly that includes complete console panel assemblies, panel interconnecting cables, and any other cables required for connection to other complete units or racks or console assemblies. |
| Countdown | Series of numbered events and checks that take place from the start of rocket-launching operations until the vehicle lifts off the launch stand. |
| Degree of Failure | The number of components in a system which must fail (regardless of their failure mode) in order to cause mission failure. First order failures are mission failures caused by a malfunction of a single component. Second and higher order failures are defined in a like manner. |

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| Deliverable GSE | The equipment used on a permanent basis in a NASA facility (S&ID, ARM and MSC) to support checkout or test spacecraft and vehicle. |
| Distributor ("J" Box) | A central termination point for electrical wiring that provides the capability for collecting and rerouting wires. |
| End Item | A final combination of products, component parts, or materials that are ready for their intended use (e.g., command module, service module, guidance system, launch escape). |
| Essential Repair | Only those repairs, bench checks, functional checks, adjustments, tests, and work necessary to ensure that an end item is restored to a serviceable condition and will efficiently accomplish its intended purpose. |
| Experimental Evaluation Test | Tests (predominantly component) that are conducted to evaluate the ability of a part or subsystem to meet the basic performance requirements. |
| Failure Mode Analysis | An orderly and qualitative listing of the manner in which components in a system can fail, the causes of the failures and their effects on vehicle ability, and the degree of the failures. |
| Failure Mode | The manner in which equipment malfunctions (e.g., short or open circuit) for electrical malfunctions and (closed or open) for mechanical valves. |
| Flight Assurance Tests | Tests for verifying that the vehicle and/or spacecraft is ready for flight. Tests include source and receiving inspection, in-process tests, combined systems tests, and acceptance tests of deliverable flight articles. |

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| Flight Sequencer | A relaying device, actuated by the flight programmer, to initiate actions which must be amplified before the programmer command can be effected. The flight sequencer also permits manual stepping of functions for checkout or other purposes as well as affording relay burn-out protection for the program device. Also referred to as stop timer or pulse timer. An assembly that receives voltages (from the programmer or GSE) and in turn distributes an output voltage to other assemblies and/or to the vehicle. The input and output voltages are usually 28 volts dc. |
| Flight Testing | A program of instrumented boilerplate and prototype module boosted flights from AMR and other selected locations to obtain and store design, design verification, system verification, and performance data. |
| Gantry | The gantry is a crane-type structure, with platforms at different levels and is used to erect, assemble, and service large rockets or missiles. It may be placed directly over the launching site and rolled away just before firing. |
| Government Furnished Equipment (GFE) | Items furnished to contractors by the United States Government. |
| Ground Equipment Test Set (GETS) | Test equipment used to verify the operational readiness of certain electrical items of GSE prior to mating with the vehicle and/or spacecraft. |
| Ground Support Cycle Flow Diagram | A functional diagram prepared by a contractor during the developmental phase of a system to depict the sequence of organizational ground support operations and the location and interactions of position functions involved in the checkout, servicing, and repair of equipment. |

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| Ground Support Equipment (GSE) | All ground equipment that is part of the complete system and that must be furnished to ensure complete support of the complete system. Included are all implements or devices required to inspect, test, adjust, calibrate, assemble, disassemble, transport, safeguard, record, store, actuate, service, repair, and otherwise support and maintain the functional operating status of a complete system, subsystem, end item, or component. It includes ground-based training, simulation, and auxiliary power devices. |
| Hatch | A door or panel which provides an opening through the pressurized structure of the command module, either directly to the outside or into an airlock. |
| Hold | Scheduled or unscheduled delay or pause in the launching sequence or countdown of a missile or space vehicle. |
| Hold Down Test | Testing of some system or subsystem in a missile or other vehicle while the vehicle is restrained in a stand. |
| Indication | A means to show the status of an event; e.g., panel lights "indicate" such things as power transfer, $LO_2$ filling, power ON, etc. |
| In-process Tests | Inspection tests performed to ensure that each step in the manufacturing process is conducted in conformance with applicable documents and specification requirements. |
| Instrumentation Systems | Combined measuring and telemetering systems. |
| Interface | An interface is the physical interaction between two parts, components, subsystems, etc., or any mode of contact between two or more elements, including the crew during any operation of a system through either direct contact or any such as visual, audio, power, etc. |
| Launch | The phase of operations beginning with the count-down and ending with lift-off. |

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| Launch Commit | That time when vehicle is actually released, i.e., the point of no return. |
| Launch Control Center (LCC) | The location or building from which a launch operation is directed. |
| Launch Operations Directorate (LOD) | One of the major divisions of MSFC which has the responsibility for receiving, handling, and launching of vehicles. |
| Launch Vehicle | The portion of a space vehicle that provides the forces and capability for placing the spacecraft at a prespecified velocity, position, and attitude. |
| Maintainability | A quality of the combined features of material design and installation which permits or enhances the accomplishment of maintenance by personnel of average skill under the environmental conditions in which the maintenance will be performed. It includes repairability and serviceability and is a function of the rapidity and ease with which maintenance operations can be performed to avert malfunctions or correct them if they occur. |
| Maintainability Characteristics | Design features which minimize the requirements for special tools, GSE, facilities, high skill levels, training, inspection, servicing, and test as well as removal, replacement, and overhaul operations. |
| Maintainability Requirement | A comprehensive statement of required or desired features or characteristics to be incorporated in equipment design to enhance or permit the ease of maintenance. |
| Maintenance | The servicing, repair, care, modification, or other action taken to keep material or equipment in or restore it to such a condition as to meet programmed operational requirements. |

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| Maintenance Analysis Specification | An analysis of each functional element of a specific system and its functional subsystems or equipment and operational GSE items in order to functionally define their maintenance requirements. |
| Major Subsystem | The major functional part of a weapon system, spacecraft, or vehicle that is essential to operational completeness. Examples are airframe, propulsion, armament, guidance, communications, etc. |
| Measuring System | The system that converts any physical quantity, phenomenon, or action to proper form for recording or transmitting via telemetering link. Included in this system are the end instruments (gages, transducers, detectors, etc.), signal conditioners, distribution systems, and other items necessary to produce calibrated electrical outputs. These outputs are usually normalized to provide 0 to 5 volts dc into 100 K ohms impedance. |
| Modification | The physical alteration of a system, subsystem, or equipment to change its designed capabilities or characteristics, any change or correction in equipment structures, arrangement or accessories affecting capabilities or characteristics. |
| Module | A combination of assemblies, subassemblies, and/or components contained in one package or so arranged together they are common to one mounting providing a complete function to the system or subsystem in which they operate. Sometimes called black box.<br><br>The term is used in conjunction with an adjective to identify the major end items that make up the spacecraft, e.g., command module, service module, lunar landing module, etc. |

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| Monitor Panel | A panel which is connected to an assembly or system and which has no means of control and contains devices for indicating operating conditions. |
| Operational | The support given a system from those items of equipment, skills, techniques, and forces that come into play during operations but are not normally identified as components of the system. |
| Panel | The front plate of an assembly upon which operational controls and indicating devices are normally mounted. |
| Panel Assembly | A subassembly or a complete rack assembly that includes panel, chassis, and all related components. |
| Complete Part (Detail Part, Component Part) | An article that is not operationally useful in itself but is an element of a subassembly, assembly, or a component and is of such construction that it is practically or economically not amenable to further disassembly for maintenance purposes. Examples: resistor, conduit bushing, fixed capacitor, transformer, hermetically sealed relay, electron tube, switch, socket, etc. |
| Part, Approved | A part considered acceptable for an application based on engineering evaluation and past usage but which has not passed a qualification test. |
| Parts, General | Usually high-population parts with essentially universal usage. |
| Parts, Peculiar | Usually low-population parts, possibly unique to a given equipment or set. |
| Passive Components | Any components of a system which do not provide specific dynamic responses for their operation, such as structural members, helium bottles, lines, fittings, etc. |

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| Postflight | The period of operations beginning with completion of the mission and ending when the final flight-test report is completed. |
| Power Transfer | The transfer of the vehicle bus system power feed from the ground supply to an internal vehicle source, i.e., batteries, fuel cells, etc. |
| Prelaunch | The phase of operations beginning with arrival of the space vehicle elements at the launch site and ending with the start of the launch countdown. |
| Preventative Maintenance | The care and servicing by personnel for the purpose of maintaining equipment and facilities in satisfactory operating condition by providing for systematic inspection, detection, and correction of incipient failures either before they occur or before they develop into major defects. |
| Prime Equipment | As assemblage of mechanical and/or electrical components having a primary purpose other than for the maintenance of other equipment. Prime equipment and the men and machines required to supply, operate, and maintain it are commonly called a system. |
| Procedure(s) | An outline (possibly in detail) of the manner or method of proceeding in a test or checkout of an assembly, subsystem, system, or composite vehicle. |
| Process Specification | A specification written as supplementary engineering instructions to establish and assure uniformity of manufacture and test methods or procedures that are essential to the fabrication and test of a product. |
| Program Manager | Responsible for all aspects of program management including business, administration, and technical aspects. In this capacity the program manager represents the president's office. |

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| Programmer | Also referred to as a program device. An assembly that originates signals to other assemblies or vehicle/stage systems that are time referenced to a known time. |
| Prototype (Preproduction Model) | A model (of spacecraft, or other equipment) that is suitable for complete evaluation of form, design, and performance. It utilizes approved parts and is representative of the final equipment. It follows an experimental model and precedes the production model. |
| Rack Assembly Complete | An assembly which includes rack, complete panel assemblies, panel interconnecting cables and any other cables required for connection to other complete units or rack or console assemblies (i.e., other external cables are required if no other means of hooking to the rack via connectors is supplied). |
| Radio Interference | Any undesirable radio frequency signal which causes a malfunction or degradation of operation of any system or subsystem. |
| Readily Accessible | Accessible by persons of 5th to 95th percentile size without requiring removal or loosening of fasteners that need tools to operate them but not requiring tools for removal or replacement. Unusual dexterity or strength is not required; and persons with hand sizes ranging from 5th to 95th percentile length, width and thickness are not prevented from performing the task. |
| Red-Flag Component | Any single component of a system whose failure in any mode would cause mission loss (deferred failure mode). The purpose of the "red-flag" label is to emphasize the criticalness of the component. This emphasis is implemented by special design analysis and quality assurance requirements. |
| Reference Designation | A reference designation is a number or combination of numbers and letters which identify parts, subassemblies, assemblies, and units. |

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| Reliability (Equipment) | The probability that an item will perform satisfactorily for a specified period of time when used in a manner and for the purpose intended. |
| Repairability | The probability that (1) when maintenance action due to equipment malfunction is taken, the system will be restored to a satisfactory operating condition in a given period of time with a given manpower expenditure; and (2) the equipment will remain in satisfactory operating condition for a specified period of time. |
| Repairability Parameters | Measures used to determine the repairability of equipment, including time to diagnose and isolate malfunctions, time to repair malfunctions and time to return equipment to satisfactory operating condition; manpower and skill levels required to repair the malfunction; and time the equipment is operating satisfactorily without requiring corrective maintenance. |
| Restricted Accessibility | Parts having restricted accessibility include those requiring multiple disassembly operations before being able to see, grasp, adjust, or remove. Also included, are those requiring unsoldering or removal of rivets, welds, or glove bonds before access is obtained. |
| Safety Relay | A relaying device usually of the one-shot variety which ensures that a function has or has not occurred until proper action has been taken. |
| Scrub | Vernacular for cancelling out a scheduled test firing before or during countdown because of weather conditions or problems in the world-wide tracking network. |
| Servicing Equipment | That equipment which handles fluids (gases or liquids) during servicing, calibration, and checkout. |

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| Serviceability | A function of equipment design, configuration, installation, and operation which results in minimization of maintenance requirements, including the use of special tools, support equipment, skills, and manpower. It enhances the ease of performing maintenance and reduces expenditure of time and material. |
| Service Test Model | A model used for test under service conditions for evaluation of suitability and performance. It closely approximates the final design, has the required configuration, and employs approved parts of their interchangeable equivalents. |
| Servicing | The performance of any established act that is required to keep an item of equipment in tolerance by preventative action, such as lubrication, fueling, oiling, cleaning, processing, etc. |
| Shelf Life | The period of time that an item will be in serviceable condition until it must be replaced because of its physical characteristics or effects of deterioration. |
| Simulator | An input device to bring about a result from an assembly, subsystem, or system. |
| Source and Receiving Inspection | Inspections conducted to ensure that all equipment received from all sources are in conformance with all applicable drawings, documents, and specification requirements. |
| Spacecraft | A version of the payload stage of the space vehicle, manned or unmanned. (Spacecraft + launch vehicle = space vehicle). |
| Spares | Accepted assemblies or parts which are available from the central warehouse and the test checkout and launch sites for immediate replacement if required. |

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| Special Test Equipment | Equipment of such a specialized nature or design that its use at the time of acquisition is limited to the performance of the particular service for which it was acquired. Includes, but is not limited to, laboratory test equipment, non-deliverable GSE, flight test instrumentation, and systems measuring devices. |
| Specification | A clear and accurate description of the technical requirements for a material, process, product, or service, including the procedure by which one can determine that the requirements have been met. |
| Stable Platform | An assembly or subsystem containing stabilizing gyros with rotating mass that provides a space-fixed reference. Also, it may contain accelerometers and may provide an output indicating vehicle attitude. |
| Static Test Article | The piece of hardware that is to be used for structural test purposes. Those portions of the article that would not affect structural strength may be omitted. |
| Subassembly | Two or more parts which form a portion of an assembly or a component that is replaceable as a whole but having a part or parts which are individually replaceable. |
| Subcontractor | Any contractor who contracts with a prime contractor, an associate contractor, or another subcontractor in fulfilling a contract. The subcontractor's relationship to the Government is indirect. |
| Substitute (Stage Electrical) | The function of a stage substitute is to electrically simulate components and circuits of stages adjacent to the stage under test in order to verify interface. |
| Subsystem | A major functional part of a system, usually consisting of several equipments or components that are essential to operational completeness of the system, such as airframe, navigation, communication. |

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| System | An organized arrangement in which each component part acts, reacts, or interacts in accordance with an overall design which adheres in the arrangement. It includes all equipment and associated personnel integrated to perform a defined task. |
| System Analysis (Troubleshooter) | Locating a malfunctioning assembly or sub-assembly of a component by means of a logical analysis of data flow diagrams of the system. The individual makes decisions with respect to appropriate checks on the basis of his determination of the relationships between the various data flow chains of information and the obtained symptom pattern. |
| Terminal Distributor | A junction/termination point for cables of excessive length provided to facilitate handling and installation, e.g., two main terminal distributors are provided in the block house cabling. |
| Test Equipment | Equipment designed and built to engineering or manufacturing drawings or specifications for the purpose of conducting a given test or series of tests of a product or in the furtherance of a research and development effort. |
| Test Plan | A document which (1) identifies in detail test objectives, planned milestones, and the reports required; (2) establishes the test concepts to be employed; and (3) identifies the support and reporting responsibilities of all participants. |
| Topping the Tank | Ground propellant supply system adjacent to the launch stand that replaces the boiloff or vapor loss of the propellant. |
| Transporter/Launcher | Structure for transporting the vehicle from the AMR assembly building to the launch pad and includes the complete umbilical tower. |

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| Umbilical Arms | Structural arms projecting from the umbilical to the space vehicle supporting the fluid and electrical lines required during prelaunch checkout. |
| Umbilical Connections | The electrical, hydraulic, and pneumatic connections between the GSE and the vehicle. |
| Umbilical Tower | Part of the launcher/transporter utilized for support of umbilical arms, fluid lines, and electrical lines for prelaunch checkout. |
| Unit (Component) | Denotes a portion or part of an assembly that is replaceable. |
| Vertical Checkout | Systems/subsystems tests performed with the vehicle/stage in the vertical position. |
| Vertical Launch Facility (VLF) | A facility for launching vehicles that are erected in a vertical plane. |